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**Emergency Food Delivery:
A State-Of-The-Art Assessment**

David J. Bjornstad
F. Paul Baxter
Ivars Gutmanis

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Energy Division

EMERGENCY FOOD DELIVERY:
A STATE-OF-THE-ART ASSESSMENT

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Several recommendations are developed which deal with the following: (1) FEMA should develop a more detailed working relationship with the Department of Agriculture (USDA); (2) FEMA should prepare better documentation of its own emergency feeding procedures and guidelines; (3) FEMA should test some previously developed options; (4) FEMA should evaluate several past studies to determine their current relevance; and (5) FEMA should undertake several new studies.

The report is presented in five chapters and an extensive bibliography. A summary of findings and recommendations is given in Chapter 1.

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ABSTRACT

The purpose of this report is to provide a critical literature review of the state of the art in emergency food supply issues, to relate these issues and literature to the mission of the Federal Emergency Management Agency (FEMA) and to recommend areas where improved information and documents would allow FEMA to more effectively perform its mission. Four major topics are addressed: (1) the institutions which participate in emergency food delivery; (2) the factual dimensions of U.S. agriculture as they relate to emergency food delivery; (3) short-term emergency feeding issues; and (4) long-term emergency feeding issues.

Several recommendations are developed which deal with the following: (1) FEMA should develop a more detailed working relationship with the Department of Agriculture (USDA); (2) FEMA should prepare better documentation of its own emergency feeding procedures and guidelines; (3) FEMA should test some previously developed options, particularly the preattack food relocation program; (4) FEMA should evaluate several past studies to determine their current relevance, particularly those carried out in the 1960s whose conclusions rest upon the technology of the agricultural and food processing sectors; and (5) FEMA should undertake several new studies, particularly regarding new developments in the international food market.

The report is presented in five chapters and an extensive bibliography. A summary of findings and recommendations is given in Chapter 1.

1. INTRODUCTION AND SUMMARY

1.1. INTRODUCTION

This report deals with (1) feeding the population when the normal means of obtaining sustenance have been disrupted and (2) the activities that would be undertaken to restore the food delivery system to its normal capacity. This is one of a series of state-of-the-art research assessments prepared for the Federal Emergency Management Agency (FEMA) by the Oak Ridge National Laboratory (ORNL).

FEMA has broad responsibilities for the management and coordination of federal efforts in preparing for and dealing with emergencies. These research assessments are intended to provide FEMA staff with a review and synthesis of the technical literature for several individual emergency-related topics and to identify areas where additional information would permit FEMA to carry out its mission more effectively.

Most federal expertise and responsibility in the area of emergency feeding and the food system reside with the U.S. Department of Agriculture (USDA). FEMA's responsibilities lie in coordinating emergency food efforts with other federal, state, and local emergency efforts and in providing leadership to other agencies during emergency circumstances so unique that normal experience is inadequate. To the degree possible, the material in this report has been focused on FEMA's role, thereby reducing the potential scope of the effort and leading to a more compact set of issues and recommendations of direct relevance to FEMA. Although FEMA has responsibility for a broad range of disaster circumstances, its primary responsibility, as well as that of its

predecessor agencies, has been civil defense, and much of the literature available on emergency food actions concerns this topic. The scope of this report, however, encompasses other disaster situations as well.

1.2 OVERVIEW OF DISASTER TYPES

Food production, processing, transportation, storage, and distribution systems in the United States have never been disrupted in a manner that has widely impacted the availability of food staples. While this does not rule out the possibility of future national food shortages, the examples of food system impacts that have been observed in the United States have been much more limited. Most have occurred at the local level and have involved emergency feeding for limited numbers of people over short time spans. Other fairly minor occurrences have affected the supply of individual food items in particular locales as a result of either natural or man-made emergencies (e.g., shortages of Florida orange products because of freezes and shortages of staple food products in Hawaii because of a longshoreman's strike).

A number of studies have analyzed the potential impacts on food production, processing, transportation, storage, and distribution systems in the event of various disasters, with food supply issues before, during, and after a nuclear attack receiving the most attention. A lesser number of reports have analyzed various factors related to food supply in the event of major natural or man-made disasters, such as earthquakes or a nuclear power plant accident. Finally, a relatively small number of studies have reported on food supply issues relating to minor and local emergencies.

The specific characteristics of emergency conditions (type, severity, spatial and temporal dimensions), together with the particular food products under consideration and the processing, transportation, storage, and distribution requirements of the food products, determine the impacts on the food supply system. The literature identifies many types of emergencies, both man made and natural, that either have occurred or may occur in the United States. Table 1.1 lists 25 major emergencies covered in the literature. All of these could potentially disrupt components of the food supply system.

This list indicates that some types of emergencies, as they relate to foods, are of marginal concern to FEMA. This is not to suggest that these types of emergencies should not be the focus of public concern and policy. Rather, actions to mitigate the food-related effects of such emergencies are taken by organizations other than FEMA. In addition, the effects of many emergencies are either similar or identical and little is to be gained by examining each individually.

FEMA's responsibility for emergency food supply management is focused on large-scale emergencies (in spatial, temporal, and functional terms) such as nuclear attack, catastrophic earthquakes, significant nuclear power plant incidents, large-scale hurricanes, tsunamis, flooding, and other similarly large natural and man-made disasters. In addition, very low probability but high-consequence events, such as an explosion of a liquid natural gas tanker, asteroid impacts, or massive changes in climatic conditions, could also be added to this list.

However, FEMA's role in assuring adequate food supply in the case of limited and/or localized emergencies cannot be dismissed entirely because

certain current regulations require FEMA to coordinate and participate in the mitigation of some localized disasters. While it may be necessary for FEMA to participate in the mitigation activities of these emergencies, FEMA's role need not be dominant or significant because other federal agencies have historically had direct responsibility for the food supply in such emergencies. Because one purpose of this study is to advise FEMA on the adequacy of the literature for its purposes, a more thorough review of the institutions that participate in emergency food delivery is in order. This review is presented in Chapter 3.

Finally, food and feeding issues are distinguished from other emergency issues by the uniqueness of the agricultural sector. This sector is heavily enmeshed in governmental programs and policies, subject to a variety of economic forces, both foreign and domestic, that are highly technological yet subject to the vagaries of weather and climate and driven by severe timetables for planting, cultivating, fertilizing, and harvesting. In spite of all this, the agricultural sector is highly productive and forms the backbone of emergency feeding options associated with post-nuclear-attack feeding. To provide a necessary background for the emergency actions discussed in Chapters 4 and 5, Chapter 2 provides a factual overview of the agricultural sector.

Table 1.1 Description of emergencies and their effects

Emergency	Definition	Effects	
		General	Food Supply
Terrorist Acts	Hostile actions against capital stock and/or population by groups or individuals, to secure objectives of a cause through terror and fear-oriented hostility and violence	Destruction of capital stock, loss of life, and injuries	Marginal effect, if any, unless the food industry is directly targeted
Air Pollution	Contamination of ambient air with a gas, aerosol, or particles which interfere with "normal" biological functions	Interference with health of population, livestock and plants	No effects or very marginal effects
Chemical Pollution	Chemical contamination of terrestrial and/or water environments; threatening to interfere, or actually interfering, with "normative biological functions"	Effects depend upon the use of the affected environments; affects health of living organisms, food yields, and water quality	Crops, fish and livestock can be contaminated but in most cases to a marginal extent
Industrial Sabotage	Destruction of industrial facilities and capabilities through covert and/or violent means	Destruction or disruption of production, processing or delivery phase of targeted industry, company or organization	Destruction of facilities may cause minor disruptions in particular for supply systems
Strikes	A temporary stoppage of work by a body of workers to enforce compliance with demands made on an employer	Stops or slows targeted activity directly and may delay upstream and downstream activities if the strike is sufficiently broad to cause a bottleneck	No effects or very marginal effects except that stoppage may destroy crops in field and delay the availability of some food items
Avalanches	Movement of large mass of snow, ice, earth, rock or other material in swift motion down a mountainside	Natural and/or man-made surface features and objects may be altered or destroyed by the force and substantially or completely buried by the accumulated slide material	No effects or very marginal effects except for food supplies stored in structures impacted by an avalanche. Food transportation by road and rail may be temporarily interrupted
Landslides	Surface masses of slope-forming material lose their bond or grip on underlying and stable floors and move outward and downward. The loss of bonding can be triggered by other events such as earthquakes or prolonged, saturating rain. The advancing mass may be preceded by an air blast and may cause damaging water waves and flooding if the mass enters a body of water	Destruction of physical facilities in the path of the landslide	No effects or very marginal effects. If effects do occur, these are localized and may disrupt road and rail transport routes used to transport food through the affected area, thereby affecting other areas indirectly

Table 1.1 (Cont.)

Emergency	Definition	Effects	
		General	Food Supply
Forest and Grass Fires	Uncontrolled, destructive burning of a dense growth of trees or underbrush or grasses covering a large tract	May destroy physical plant in urban neighborhoods, agricultural fields and forests; communications and utilities	May result in marginal loss of food stores, crops livestock, food processors, and transit facilities
Tornadoes	A violent, destructive whirling wind accompanied by a funnel-shaped cloud that progresses in a narrow path over the land	Concentrated devastation of structures and vegetation and lives in the direct path	Marginal effects limited to the path of the tornado
Windstorms	Strong, non-tornado winds caused by fast-moving frontal passages, thunderstorms and squall lines	Damages to upright objects and structures	No effects or marginal effects
Earthquakes	A shaking or trembling of the earth that is volcanic or tectonic in origin	Effects depend on the severity of the earthquake and may range from no effect to a complete destruction of physical plant in the area of the earthquake	Effects range from no impact to severe damage to food supply system, structures, crops and transportation
Winter Storms	Relatively intense storms along boundary of cold polar and warm tropical air masses	May impact on road and transportation systems; utilities may be interrupted	No effects or marginal effects
Heat Waves	Climatic shifts from alternating weather patterns	May impact on plants and animals because of reduced moisture, which alters biological functions, especially of plant reproduction	May have limited effect on crop yields
Frosts and Freezes	Covering of minute ice crystals on cold surfaces; a state of weather marked by low temperature, especially when below the freezing point	Effects on biological functions of plants	Frosts may damage agricultural crops; freezes may damage blossoms; damages are local and limited
River Floods	A rising and overflowing of a body of river water	May result in structural damages such as submergence of structures, houses, crops, and transportation routes	Effects are marginal;
Hurricanes	A tropical cyclone with winds of 74 miles per hour or greater that is usually accompanied by rain, thunder, and lightning and that sometimes moves into temperate latitudes	May result in wind damage to physical plant, flooding due to rain and storm surge. Heaviest damage in coastal areas	Effects are marginal; result in loss of crops, livestock, food inventories
Tsunami	A great sea wave produced by submarine earth movement or volcanic eruption	May result in marginal effects to complete destruction of utilities, structures, transportation infrastructure industry on the coast and up to a mile or so inland	Effects marginal but result in destruction of local retail and wholesale food supplies and distribution facilities. Coastal transportation utility infrastructure may be lost for some periods

Table 1.1 (Cont.)

Emergency	Definition	Effects	
		General	Food Supply
Transnational Fallout	Pollutant particles carried across national boundaries in the air and subsequently descending through the atmosphere	May interfere with "normal" biological processes	No effects or very marginal effects
Droughts	A prolonged period of dryness	Effects depend on the severity of drought but may result in climatic dryness which may be severe enough to reduce soil moisture and water below the minimum necessary for sustaining plant and animal life systems	May result from significant to severe reduction in food production and agricultural activity
Firestorms	Very high intensity fires, self-fueling, accompanied by very high velocity winds	Complete destruction of physical plant	Food supply system destroyed in affected areas
Reactor Accidents	Malfunction of nuclear power reactor, may include leakage of radioactivity	Effects may range from complete destruction of an area or region surrounding the nuclear power facility to no effects of any kind	Effects may range from significant impact on supply system to marginal or no effects
Volcanic Eruptions	Issuance of molten or hot rock, ash, and steam through a vent in the earth's surface	Effects may range from very severe in the areas affected to marginal or none at all	Effects may range from very marginal to significant interference with crop and livestock production
Bacterial Accidents	Unintended release of bacteria capable of causing undesirable effects to human health and plant or animal life	Effects may range from significant to marginal	May affect food supply (crops, livestock, dairy products, etc.) and processing
Asteroid Impact	Collision of a planet, having a diameter of 5 miles or less, with the earth	Effects measures must be speculative because of insufficient history, but more likely than not catastrophic impact on physical plant, population, and activities worldwide	Most likely very significant, even catastrophic, worldwide
Nuclear Attack	Limited or extensive exchange of thermo-nuclear weapons which may take place over extended time period	Short-term effects include blast, shock, firestorms, radiation. Long-term effects include radiation and related impacts	Very significant in impacted areas

1.3 SUMMARY AND RECOMMENDATIONS

Four major topics are addressed in this report: (1) the institutions that participate in emergency food delivery; (2) the factual dimensions of American agriculture as they relate to emergency feeding; (3) short-term emergency feeding issues; and (4) long-term emergency feeding issues.

The first major topic concerns the organizations that provide emergency food services. This is given detailed treatment to identify FEMA's role within the set of emergency feeding institutions and to discover gaps in responsibility which may exist.

In general, responses to emergencies start at the local government level and are elevated to higher levels of government, usually at the request of the lower level, as the capability of the lower level of government is exceeded. Although emergency food activities can involve any phase of the food cycle, e.g., growing, transport, processing, distribution, or consumption, typically they concern the short-term distribution of foodstuffs to limited numbers of persons over a limited area. Such a distribution would commonly follow a disruption that caused the displacement of families, such as a flood, hurricane, or tornado.

In these instances, the agency of first recourse is usually the American Red Cross. Efforts by the Red Cross may be augmented by the National Voluntary Organizations Active in Disasters or by other public or private groups. As the scope of the disaster increases, the role assigned to the volunteer organizations tends to decrease because volunteers are typically imported from nonaffected areas and serve at

their own convenience. At the limit, during a declared Presidential emergency taking place over a widespread area, professional workers, or the military, would likely be required.

Based on the available literature, it does not appear that the government is currently prepared to take over the role of the Red Cross, i.e., mechanistically providing feeding services at the level necessary to accommodate a disaster as severe as a nuclear attack. FEMA should ensure that plans to do this are prepared.

Emergencies can also affect other components of the food cycle. Federal responsibilities for non-feeding components have almost uniformly been assigned to the USDA. A reading of the literature suggests that while the USDA has vast experience in the workings of the food system during normal times, it has had much less experience with the extraordinary conditions of a severe disaster. However, its internal plans for carrying out emergency food activities, backed by written reports, appear more complete than those of FEMA.

An appropriate role for FEMA, and one which FEMA has partially filled, is the provision of leadership in times when business-as-usual practices must be suspended--for example, in times of war. FEMA could, for example, provide guidelines to replace food inspection "standards" appropriate under normal conditions with standards appropriate under dire circumstances, or it could provide the responsible agencies with detailed information on various disasters to permit these agencies to form their own alternative standards.

It is recommended that FEMA develop a continuing relationship with the USDA, at the working level, to identify gaps that may exist in the

assignment of responsibilities for the components of the food supply system during emergency times. In doing this, particular attention should be paid to guidelines that indicate departures from business-as-usual practices. Responsibility for these departures should be established. Finally, procedures requiring interagency cooperation should be exercised in simulated circumstances whenever practical and possible.

The second major topic is an overview of the U.S. agricultural system which, along with providing a description of this sector, reaches several conclusions. It is noted first that the agricultural sector is highly productive, meeting all American nutritional needs and most food-related wants. Exceptions tend to be such specialty foods as teas, coffees, seafoods, and certain exotic fruits. As well, the sector provides a healthy export component to the nation's international trade accounts.

This suggests that it is unlikely that the nation will "import" a food crisis (i.e., that a foreign food crisis will endanger U.S. citizens). On the other hand, the United States might well "export" a food crisis. This is to say that many nations of the world rely on American food exports. A disruption to U.S. production would place world food markets in jeopardy.

It also suggests that it would be quite difficult for U.S. food shortages to be made up through trade with the rest of the world. Canada would be the most likely source of foodstuffs in the event of a severe emergency; however, Canada could well suffer emergency effects similar to those in the United States. One concludes that the United States must

take responsibility for its own food problems at a minimum and much of the world's at a maximum.

A second conclusion is that in many agricultural sectors, productivity has been obtained by substituting the products of other industries for labor. Although because of the sector's diversity there is danger in generalizing, farms tend to use large amounts of capital, fertilizer, and herbicides and pesticides, as well as fuels to operate equipment. To the extent that these inputs are required along fairly narrow time frames, there is the possibility that a disruption could massively affect the productivity of the sector. It is not clear exactly how changes in farming operations affect the validity of emergency preparedness research conducted in past decades; but, if anything, the sector has become more sophisticated and the impacts from disrupting the input flow are greater.

Finally, several natural "cushions" reduce the vulnerability of the sector. These include the vast territorial expanses across which production is dispersed; the existence of a fairly substantial annual surplus which is commonly exported, stored, and/or distributed through special federal programs; and the extensive feeding of livestock. These cushions would be most useful if plans were laid prior to the need to use them. An example of such a planning exercise is the national security food requirements project, conducted at ORNL for FEMA.

It is recommended that a study be conducted to describe the role of U.S. agriculture in world food markets and the impacts that would occur if these exports were cut off. A series of smaller studies should also be undertaken to discover if changes to the agricultural sector in the

past two decades invalidate research carried out during the 1950's and 1960's, particularly the conclusions drawn concerning the resiliency of agricultural outputs if input streams were disrupted. Finally, ways to use natural cushions that characterize the agricultural sector should be determined and plans to exploit these should be made before the fact. FEMA should generally be responsible for these studies because of its lead role in emergency planning. All of these studies, however, should be reviewed and critiqued by the USDA.

The third major topic is short-term activities undertaken to cope with food emergencies. In general, short-term activities are concerned with emergency feeding to prevent starvation. To characterize short-term actions, preincident, transincident, immediate, and near-term actions are distinguished. Most of this research was sponsored by FEMA and predecessor agencies and deals with civil defense and nuclear attack.

Preincident and transincident time frames are primarily directed toward civil defense preparations. In particular, a series of reports has examined possible ways to redistribute retail and wholesale supply lines to meet the food needs of an evacuated population in anticipation of a nuclear attack. It has been estimated that several weeks' provisions are available as goods in process or in inventories. These studies provide detailed plans to carry out this redistribution. It is generally felt that these plans are an adequate base upon which to plan a feeding program for persons evacuated in anticipation of nuclear attack, though this has apparently not been verified (i.e., unclassified writeups were not found).

Transincident food provision generally refers to feeding concerns during the time spent in shelter during a nuclear attack or during the period immediately following an attack while fallout remains dangerous. A number of studies have examined this issue, but because of the expiration of the nation's shelter foods program and changes in the food processing industry, these are not now being pursued actively. It is felt that were this issue to resurface, reevaluation of the food preservation literature would be useful. It would also be helpful to assist private and individual efforts in food storage for this purpose.

Immediate feeding activities are undertaken following a disaster to prevent starvation. Several stages in this process can be identified: identifying the location of persons to be fed and their food needs, transporting food to this population, and distributing the food. Issues in general nutrition are well understood, and no additional research is needed. However, only a few official publications are in a form that can be easily used by a lay person. Therefore, individuals who wish to make private preparations often rely on non-government documents, some of which are quite useful. Moreover, because current policy does not call for the development of detailed evacuation plans, locating the individuals to be fed in a widespread disaster would require very timely information. Difficulties in transporting and warehousing of foodstuffs following a disaster would vary with the scope of the disaster. Truck transport is generally considered the most feasible option because of its flexibility. Warehousing would be complicated by evacuation, which would tend to move people away from existing warehouses, and also by the

effects of the disaster, such as lack of electricity for refrigeration, contamination of food, etc.

Another major short-term consideration is screening of food for contamination following a major disaster, such as nuclear attack. Perhaps the most difficult area is the treatment of animals, particularly the determination of if and when to slaughter them and how to prepare them. Emergency action documents that address the use of scarce foodstocks for animal feed should be prepared in advance.

Finally, as was suggested previously, a major short-term feeding option is provided by the nation's stores of surplus grains. However, for the reasons cited, in addition to the general volatility of grain stores over the growing season and between years, it is important that an information system to maintain current information on stores be constructed. Because an evacuation would probably be undirected, it would be very difficult to predict when foods would be needed, and this information would likely arise incrementally as foods shortages occurred. Thus, a flexible method of distribution that could rapidly assimilate new information would be required.

It is recommended that a test exercise to evaluate the preattack food relocation program be developed and applied if this has not yet been done. A small study should be performed to review recent developments in food preservation and how they could be used in preserving emergency food stocks for shelters. This and other information that might be used by individual households should be reviewed for clarity and ease of use. Research should be conducted to determine the most likely locations of evacuated persons following a major disaster under alternative evacuation

policy assumptions. Systems that are developed in this regard should be information oriented and capable of easy update. Plans to carry out emergency feeding should be flexible and should incorporate significant inputs from decentralized governmental units, such as states. Guidelines for screening foods following contamination should be prepared. Of particular interest are guidelines for animals because decisions reached regarding the stock of animals would significantly affect the future herd and could potentially drain stored foodstocks.

The fourth major issue addressed in this report is long-term activities to cope with food emergencies. The distinction between long-term and short-term activities is that, while short-term activities deal with feeding to prevent near-term starvation, long-term issues center on restoration of the food supply system. Long-term emergency food actions are characterized by substantially more interaction with the rest of the economy and a good deal more competition for scarce resources. Integration and planning with other activities is therefore of primary importance. Most constraints to agricultural production will arise from a lack of chemicals and fuels. Processing of foods will also be difficult because of the need to reconstruct facilities. Transport issues change as the focus shifts to the long term because of the potential of agricultural transport to dominate demands for available equipment. Attention should be focused on restoring rail transport.

It is recommended that a study be carried out to identify potential bottlenecks in the rail transport network which, if corrected, would permit the use of trains for food transport, thus freeing trucks to perform other pressing needs. Past research on the food supply building

and equipment stock to ascertain potential damages and reconstruction difficulties from nuclear attack should be re-evaluated to determine if this work remains valid in the face of food system changes.

1.4 ORGANIZATION OF REPORT

The remainder of this report is divided into four chapters. Chapter 2 provides a factual overview of the U.S. agricultural sector. Chapter 3 contains a discussion of institutions involved in emergency food actions. Chapter 4 contains the discussion of short-term activities to cope with food emergencies, and Chapter 5 contains the discussion of long-term activities to cope with food emergencies. An extensive bibliography follows Chapter 5.

2. U.S. FOOD PRODUCTION

2.1 INTRODUCTION

As was discussed previously, the ultimate basis for emergency feeding is a nation's agricultural sector. Starting from produce, be it grain, fruits, or livestock, one can trace foodstuffs through intermediate channels to ultimate consumption. Emergencies can then be characterized by their spatial extent and their impacts upon the various stages of the normally operating food system. This approach is followed in Chapters 4 and 5, which focus on short- and long-term approaches to mitigating food shortages, respectively.

First, however, comes a factual review of the agricultural sector. Such a review is justified by the need to understand the scope of American agriculture, as well as to assess the validity of the assumptions that underlie much of the older emergency-feeding literature. This assessment is required because of the significant changes that have affected this sector.

Many of these changes are well known. During the past century and through World War II, growth in agricultural productivity paralleled the transformation of the nation from a rural agrarian society to an urban industrial one. This was accomplished, in part, by the development and deployment of technologies that drastically increased farm productivity. At the same time, the ability of the sector to produce foodstuffs was outstripping national food needs. Government was called upon to develop programs to stave off falling farm prices and incomes. Together, these influences have tended to integrate agriculture into the remainder of the

economy and to increase its dependence on governmental policy initiatives rather than on market forces.

The past decade has been particularly turbulent. Fuel shortages occasioned by the 1973 embargo and subsequent reorganization of petroleum markets drove up energy costs, and high interest rates, driven by inflation, increased the burdens to the costs of farm credit. The invasion of Afghanistan by the Soviet Union precipitated a grain embargo by the Carter Administration. This reduced the market for U.S. exports during a period preceded by a philosophy that less than a decade earlier had exhorted farmers to plant crops from "fence row to fence row." Thus, by the end of the 1970's, American farmers found themselves with reduced foreign demands for crops, higher energy and credit costs, and a rapidly increasing inflation rate.

Beginning in 1981, farm real estate values in many areas began a precipitous decline, wiping out gains achieved in earlier years and placing pressure on farmers' debt-equity ratios, the basis of much farm credit. This rapid succession of events has particularly weakened the financial position of food and feed-grain producers--that segment of American agriculture which most past research has suggested would be the mainstay for emergency rations during an extended disruption of the food system (Garland 1972, Franz 1975, Haaland 1977, Blanchard 1982, Kerley and Das 1985).

All of this suggests that today's agricultural sector may be quite different from that in the 1950's, when a number of assumptions concerning the ability of American farmers to feed the nation during

emergency conditions were developed (see, for example, Lee et al. 1968).

In particular, it is important to consider the following issues:

- How dependent are Americans on foreign food and how important are American exports to other nations?
- What flexibility exists to operate farms using "old fashioned" techniques?
- What factors reduce the vulnerability of the agricultural sector?

2.2 AGRICULTURAL PRODUCTION

American agriculture is a global food resource, serving worldwide and domestic markets. Farm productivity is largely responsible for this circumstance. In 1983 the United Nations estimated the world population to be 4.7 billion and increasing by 78 million persons per year, an annual growth rate of about 1.7 percent. At this rate, world population will reach 5 billion by 1988. Nearly 18 percent of this population (833 million) is classified as "economic agricultural producers." On the average, each of these producers is responsible for feeding 5.6 people. The total area of arable land and permanent crops is now estimated at 1.47 billion hectares, the level that has been maintained for some time. As shown in Table 2.1, a large fraction of the land (31 percent) is located in Asia, but an even larger fraction of the population is located there. In general, developed areas, such as North America, have high proportions of arable land to population, while less developed areas have the opposite.

In 1983, the U.S. population stood at 234 million, about 5 percent of the world's total, and was growing at a rate of 2.2 million persons per year. This rate, less than 1 percent annually, is about half the

Table 2.1. Comparison of world population, arable land, grain, and red meat production by continent and selected countries (1983)

Continent or country	Percent of world population	Percent of world arable land	Percent of world grain production	Percent of world red meat production
Africa	11.0	12.4	3.8	4.4
N. America	8.4	18.6	17.6	20.3
S. America	5.5	9.4	4.3	8.3
Asia	58.3	31.0	45.4	21.8
Europe	10.5	9.5	15.7	29.3
Oceania	0.5	3.3	1.9	3.4
U.S.S.R.	5.8	15.8	11.3	12.5
United States	5.0	12.9	12.7	16.7

Source: FAO Production Handbook, 1983, United Nations.

world rate. In the United States, about two million persons are "economic agricultural producers." Each, however, feeds about 116 other persons domestically, plus an additional number through exports. The distribution of "economic agricultural producers" by continent is shown in Table 2.2. The continents of Africa and Asia stand out as having high proportions of people involved in food production, while developed continents have relatively few people. About one out of each thousand of the world's food producers is an American.

Despite this small number of producers, the United States produces a significant amount of the world's food supply. Table 2.3 shows the percentage of selected agricultural products produced in the United States. These range from a high of 61 percent of the soybeans and 42 percent of the corn to under 10 percent of the vegetables, fruit, and livestock.

2.2.1 Crop Production

Crop products are of interest for emergency food planning because they are a source of a wide range of nutrients and offer the potential for storage (Kearney 1979, Franz and Kearney 1979). Under austere conditions, crop products can be used for subsistence feeding over long periods of time. They form the basis of FEMA's current national security food planning effort (Kerley and Das 1985).

The United States produces about 18 percent of the world's supply of cereals, which are predominantly wheat, rice, corn, barley, and sorghum. Wheat has historically been one of the more valuable cereals because of its use for human consumption rather than as animal feed. Rice is also an important cereal worldwide, though less so in the United States. The

Table 2.2. Distribution of economic agricultural producers (EAPs)
by continent and selected countries

Continent or country	Number of EAPs	Percent of world EAPs	EAPs as percent of continent or country population
Africa	119,295,000	14.3	64.3
N. America	17,449,000	2.1	11.0
S. America	24,639,000	3.0	29.7
Asia	618,731,000	74.3	55.5
Europe	30,473,000	3.7	13.8
Oceania	2,157,000	0.3	21.5
U.S.S.R.	19,788,000	2.4	14.5
United States	2,015,000	0.2	1.9
World	832,532,000		

Source: FAO Production Handbook, 1983, United Nations.

Table 2.3. Percentage of world production of
selected agricultural products produced
by the United States (average of
1981, 1982, and 1983)

Agricultural product	Percentage of world production produced in the United States
All cereals	17.6
Wheat	15.2
Rice	1.5
Barley	6.8
Corn	42.3
Oats	14.9
Sorghum	27.4
Soybeans	60.9
Vegetables	7.1
Fruit	8.6
Cattle	9.4
Hogs	7.6
Chickens	5.6

Source: FAC Production Yearbook, 1983, United Nations.

Note: In 1983, the world population was 4.7 billion, with 833 million (17.8 percent) of the people classified as "Economic Agricultural Producers" (EAPs). The United States, with 5 percent of the total world population, has about 2 million persons so classified.

U.S. supply of food and feed grains is almost entirely obtained from domestic production. The 1984 cereal grain production was in excess of 312 million metric tons while only 1.7 million metric tons of grains and feeds were imported. The U.S. grain supply is composed mostly of corn (62 percent) and wheat (23 percent), with the remainder consisting of sorghum, barley, rice, and oats. Domestic consumption of cereal and feed grains in 1984-85 totaled 197 metric tons, or about 43 percent of domestic output. Exports accounted for 33 percent of domestic output, and stocks of grain at the end of the year amounted to 85 million tons, about 43 percent of annual domestic output.

The world produces about 500 million metric tons of wheat per year, as indicated in Table 2.4. The United States produces about 14 percent of this amount, retaining slightly less than half for domestic use and exporting the remainder. Canada, France, Australia, and Argentina are also active in world markets. Together they produce only slightly more wheat than the United States, but export nearly twice as much.

In all, the United States consumes about 4 percent of world wheat production for human food. On a worldwide basis, most wheat is used for human food (about 80 percent), but, recently, decreases in domestic wheat prices have encouraged the use of wheat as animal food in the United States. In 1984-85, almost 40 percent of wheat not exported was fed to livestock. The world carryover of wheat amounts to about 100 million metric tons each year, with the United States accounting for 35-40 percent of this total.

Of this stored wheat, a minimum inventory usually occurs around June, just before the beginning of the winter wheat harvest in the

Table 2.4. United States and world supply of wheat (1982-1985)

Item	1982-1983 Season		1983-1984 Season		1984-1985 Season	
	Metric tons	(%)	Metric tons	(%)	Metric tons	(%)
World Production	478,600,000	100.0	490,400,000	100.0	514,400,000	100.0
U.S. Production	75,300,000	15.7	65,900,000	13.4	70,600,000	13.7
World Use	467,100,000	100.0	488,400,000	100.0	502,500,000	100.0
Animal Feed	88,700,000	19.0	92,600,000	19.0	98,100,000	19.5
Human Food and Other Uses	378,400,000	81.0	395,800,000	81.0	404,400,000	80.5
U.S. Domestic Use	24,700,000	100.0	30,200,000	100.0	32,300,000	100.0
Animal Feed	5,300,000	21.5	10,200,000	33.8	12,300,000	38.1
Human Food and Other Uses	19,400,000	78.5	20,000,000	66.2	20,000,000	61.9
U.S. Exports (% of U.S. Prod.)	41,100,000	54.6	38,900,000	59.0	38,500,000	54.5
Ending Stocks (World)	96,900,000	100.0	98,460,000	100.0	110,380,000	100.0
Ending Stocks (USA)	41,200,000	42.5	38,080,000	38.7	38,160,000	34.6

Source: World Agricultural Supply and Demand Estimates, USDA-ERS-FAS, December 11, 1984, and June 10, 1985.

southern states. In recent years, the lowest level of on-farm storage was in 1973 when 80 million bushels (2.03 million metric tons) of wheat were on hand. At the same time, there were 158 million bushels (4.1 million metric tons) in off-farm storage. These quantities constitute a 17-week supply at normal consumption rates (14.5 million bushels per week) without exports and a 6.4-week supply if exports are maintained.

Despite the efforts of a variety of governmental programs to curtail wheat production, the wheat-growing capacity of the agricultural sector has increased dramatically. This is largely because, even after programmatic restrictions, farmers still have incentives to maximize output and have turned to such devices as double cropping, improved varieties, and heavier fertilization to do so. As indicated in Table 2.5, productivity per acre, as well as total production, varies significantly by state. The 20 states listed account for 93 percent of the nation's wheat production but have only about 49 percent of the U.S. population.

The world production of corn is slightly less than that of wheat. As shown in Table 2.6, recent totals amount to about 450 million tons annually. The United States normally produces about 40-50 percent of the world corn output. This dominance was particularly evident in 1983, when U.S. corn production was almost 50 percent lower than its normal level of about 200 million metric tons. This drop resulted from the combination of a severe drought, coupled with the introduction of the payment-in-kind (PIK) price support program. As a result, world corn output in that year was about 350 million tons.

Table 2.5. Wheat production and yield in the United States (1979-1981)

State	1979-1981 average production (bu)	1979-1981 average yield (bu/acre)	Percent of U.S. total	Percent of total U.S. population
Arkansas	38,406,667	39.3	1.6	0.9
California	83,011,667	75.1	3.4	9.8
Colorado	89,306,000	29.3	3.7	1.1
Georgia	23,978,333	39.0	1.0	2.3
Idaho	86,650,000	57.4	3.6	0.4
Illinois	73,870,000	47.5	3.0	5.5
Indiana	53,461,667	47.3	2.2	2.6
Kansas	378,466,667	32.4	15.5	1.1
Michigan	36,101,667	45.8	1.5	4.4
Minnesota	112,321,667	36.0	4.6	1.9
Missouri	91,636,667	42.8	3.8	2.3
Montana	136,368,333	25.5	5.6	0.3
Nebraska	100,400,000	36.1	4.1	0.7
North Dakota	254,528,333	24.7	10.5	0.3
Ohio	67,696,667	46.8	2.8	5.2
Oklahoma	194,800,000	31.4	8.0	1.3
Oregon	70,696,667	54.3	2.9	1.0
South Dakota	70,485,000	21.4	2.9	0.3
Texas	150,466,667	27.6	6.2	5.5
Washington	148,856,667	48.6	6.1	1.7
	2,261,519,333	33.8	92.9	48.6
All States	2,433,934,000	34.1	100.0	
Other States	172,414,667	37.3	7.1	

Sources: Agricultural statistics, 1982, U.S. Department of Agriculture
Population Census, 1970, Bureau of Census.

Table 2.6. United States and world supply of corn (1982-1985)

Item	1982-1983 Season		1983-1984 Season		1984-1985 Season	
	Metric tons	(%)	Metric tons	(%)	Metric tons	(%)
World Production	437,600,000	100.0	345,690,000	100.0	449,970,000	100.0
U.S. Production	209,200,000	47.8	106,040,000	30.7	194,480,000	43.2
World Use	418,200,000	100.0	409,550,000	100.0	436,380,000	100.0
Animal Feed	259,600,000	62.1	268,200,000	65.5	300,370,000	68.8
Human Food and Other Uses	158,600,000	37.9	141,350,000	34.5	136,010,000	31.2
U.S. Domestic Use	137,700,000	100.0	119,610,000	100.0	133,360,000	100.0
Animal Feed	114,900,000	83.4	94,900,000	79.3	106,690,000	80.0
Human Food and Other Uses	22,800,000	16.6	24,710,000	20.7	26,670,000	20.0
U.S. Exports (% of U.S. Prod.)	47,500,000	22.7	47,380,000	44.7	49,540,000	25.5
Ending Stocks (World)	95,800,000	100.0	32,700,000	100.0	46,290,000	100.0
Ending Stocks (USA)	79,300,000	82.8	18,370,000	56.2	30,000,000	64.8

Source: World Agricultural Supply and Demand Estimates, USDA-ERS-FAS, December 11, 1984, and June 10, 1985.

Although corn is put to a variety of uses (including direct and indirect human consumption, as oils, and as a carbohydrate source for alcohol distillation), its dominant use is as animal feed. Worldwide, about 65 percent of corn is used for feed, while in the United States, about 80 percent is used in this manner.

The United States exports about 50 million metric tons of corn each year, which is normally about one quarter of the domestic crop. Recent world stocks have amounted to about 50 to 100 million metric tons (in October 1975, only 9.2 million tons were on hand). The United States generally accounts for about 60 percent of world stocks. At its low 1975 level, normal consumption could have been maintained for about 4 weeks if animal feeding continued and for about 35 weeks if animal feeding were curtailed.

The United States is the major world corn producer by a large margin, with 1982 yield outpacing that of China, the second largest producer, by three and one-half times. Other international producers include Brazil, Rumania, the USSR, Yugoslavia, and France. Principal buyers for U.S. exports are Japan, Mexico, Korea, the Common Market, and the USSR.

Domestically, Iowa is the leading corn-producing state, with 19 percent of national production. Iowa, Illinois, Indiana, Nebraska, and Minnesota account for over 65 percent of U.S. production. The top ten corn-producing states account for over 80 percent of production. Most production is centered in the "corn belt," a roughly 300 x 600 mile "U" shaped zone in the central plains. Although it is commonly felt that corn-growing areas are sufficiently dispersed that a single incident

could not wipe out an entire growing season, the fact remains that in 1983, national corn output was cut by one-half. Since 1969, annual corn production has ranged from 4.1 billion bushels (105 metric tons) to 8.2 million bushels (209 metric tons).

In addition to corn and wheat, soybean is another important crop (often planted in rotation with corn and wheat) that could be used in emergency food planning (Franz and Kearney 1979, Kerley and Das 1985). In terms of use, soybeans are a major source of protein in animal feed and also a source of vegetable oil. Although the crop was introduced relatively recently to the United States, this country now grows about 61 percent of the world's output. Of this approximately two billion bushels (54 million metric tons), about half is exported and about half is crushed for oil and meal. A small amount is fed directly to livestock. In 1984, soybean reserves totaled 4.8 million tons, or about 11 percent of the total output. At normal consumption rates, this would amount to a 5- to 6-week supply, or a 10- to 12-week supply if exports were curtailed.

2.2.2 Fruit and Vegetable Production

The United States imports a much larger share of fruits and vegetables than cereals and soybeans. The total market value of fruits and nuts amounted to about \$5.8 billion in 1982, while imports were valued at about \$1.1 billion. Exports of these commodities were about \$828 million.

The total annual U.S. production of fruit amounts to about 28 million tons and is dominated by citrus, grapes, and apples, followed by peaches, pears, prunes, strawberries, cherries, and avocados. States

producing significant amounts of citrus include Florida, California, Texas, and Arizona. Grapes are produced primarily in California, with lesser amounts grown in Washington, New York, Michigan, and Pennsylvania. Apples are produced in Washington, New York, Michigan, California, Virginia, and North Carolina.

The market value of vegetables produced in the United States in 1982 totaled about \$4.1 billion with imports of \$533 million and exports of \$423 million. About half the vegetable production comes from California, with another 10 percent contributed by Florida. Other important states include Texas, New York, Oregon, Arizona, and Wisconsin. Except for Wisconsin, these states tend to produce for the fresh market. Wisconsin, together with Minnesota and Illinois, produces primarily for the processing market.

2.2.3 Animal, Animal Products, and Meat Production

American meat producers account for 24 percent of the world supply of beef and 13 percent of the world supply of pork. Almost all of the meat products produced in the United States are consumed domestically, i.e., by less than 5 percent of the world's population. Relative to the rest of the world, the United States is heavily dependent on red meat.

Beef consumption in 1984 amounted to 25 billion pounds, with about 7 percent imported and less than 2 percent exported. Stocks of beef, pork, and poultry are usually very small, commonly less than 2 percent of total production. An interruption of the slaughter and processing of meat animals at any particular time would mean that about one week's supply of meat, given normal consumption levels, would be available.

Recent levels of production, consumption, imports, and exports of beef, pork, and poultry are shown in Table 2.7. Each of these meat types has similar relative values of imports and exports, except that no poultry is exported. By weight, the U.S. meat diet typically contains 44 percent beef and about 28 percent pork and poultry. Poultry consumption appears to be increasing slightly each year.

Egg production amounted to 5.7 billion dozen in 1984, with relatively small amounts being imported and exported. Consumption was about 5.1 billion dozen. Only small stores exist. Dairy production in 1984 was 137 billion pounds. Again, little was imported or exported. Stores in the form of dried milk are relatively larger than those of meat or eggs.

Finally, the United States consumes about 8 million pounds of seafood annually, of which about 60 percent is imported. The proportions of shell and fin fish imports are roughly the same. Few stocks are available.

2.3 STRUCTURE OF THE AGRICULTURAL SECTOR

The 1982 agricultural census reported that 2.2 million farms were operating in the United States, about one farm for every 100 Americans. The value of the land and buildings for these farms is now nearly \$800 billion. Annual costs of inputs include feed at \$20 billion, interest at \$14 billion, labor at \$11 billion, fuel at \$9.6 billion, machinery at \$7.4 billion, and agricultural chemicals at \$3.4 billion.

It is striking that the output from about half of these farms makes virtually no impact on the supply of food, accounting for about 3 percent

Table 2.7. United States meat supply and use (1983-1985)

Type of meat	1983	1984	1985 Estimate
Beef Production, lb x 10 ⁶	23,243	23,598	22,916
Imports, lb x 10 ⁶	1,931	1,823	1,820
Imports of total consumed, %	7.8	7.3	7.5
Exports, lb x 10 ⁶	312	376	417
Exports of total production, %	1.3	1.6	1.8
Total Consumption, lb x 10 ⁶	24,831	25,012 (44%)	24,377
Ending Stocks, lb x 10 ⁶	325	358	300
Ending stocks of production, %	1.4	1.5	1.5
Pork Production, lb x 10 ⁶	15,199	14,812	14,350
Imports, lb x 10 ⁶	702	954	1,000
Imports of total consumed, %	4.5	6.2	6.6
Exports, lb x 10 ⁶	361	331	268
Exports of total production, %	2.4	2.1	1.9
Total Consumption, lb x 10 ⁶	15,458	15,482 (28%)	15,081
Ending Stocks, lb x 10 ⁶	301	274	275
Ending stocks of production, %	2.0	1.8	1.9
Poultry Production, lb x 10 ⁶	15,766	16,392	17,308
Imports, lb x 10 ⁶	0	0	0
Imports of total consumed, %	0	0	0
Exports, lb x 10 ⁶	645	613	567
Exports of total production, %	4.1	3.7	3.3
Total Consumption, lb x 10 ⁶	15,186	15,790 (28%)	16,695
Ending Stocks, lb x 10 ⁶	275	264	310
Ending stocks of production, %	1.7	1.6	1.9

Source: World Agricultural Supply and Demand Estimates, USDA-ERS-FAS.

of the total value of farm output. In fact, a high proportion of agricultural production, by dollar value, is produced on a relatively small number of farms, as Table 2.8 shows. For example, 1 percent of all U.S. farms produce outputs valued at more than \$500 thousand each. These farms account for 32 percent of total U.S. farm output, by value, and employ 46 percent of the farm labor hired, but use only 8 percent of the machinery, by value. These farms specialize predominantly in vegetables, fruits, and nuts.

About 13 percent of the farms in the sample--about 30 thousand farms--annually produce more than \$100 thousand. This group includes 72 percent of the total value of farm production, hires 81 percent of the labor, and owns 44 percent of the machinery. It purchases 56 percent of the petroleum, 63 percent of the fertilizer, and 68 percent of the chemicals. These farms include the bulk of the wheat, corn, and soybeans production.

Although these data do not provide an exact roadmap for emergency planning, it is useful to review their importance. First, the large, so-called "corporate farms," make up about 1 percent of all farms, hire vast quantities of labor; are responsible for a third of the market value of agriculture; produce high valued crops of fruits, nuts and vegetables; and are located around the nation's southern perimeter in Florida, Texas, Arizona, and California. These organizations are largely responsible for introducing variety and quality into the unprocessed foodstuffs in the typical American's diet. However, these foodstuffs are largely nonessential for survival. Moreover, it is unlikely that these crops would be wiped out during normal times; thus, the only concern about

Table 2.8. Percent distribution of farm characteristics
by value class

Item	Value of Farm Products Sold				
	>\$500	>\$250K	>\$100K	>\$40K	>\$10K
Number of farms	1	4	13	28	51
Value of land and building	12	23	46	66	82
Value of farm machinery	8	19	44	68	85
Market value of products sold	32	48	72	89	97
Irrigated land acres	29	46	71	87	96
Corn sold	11	30	65	88	98
Wheat sold	13	29	60	85	98
Soybeans sold	9	26	60	85	97
Vegetables sold	69	80	89	95	98
Fruits and nuts sold	52	65	81	92	98
CCC loan value	14	36	72	93	100
Fertilizer purchased	17	33	63	85	95
Electricity purchased	25	38	62	83	94
Chemicals purchased	24	40	68	87	97
Petroleum purchased	15	28	56	79	93
Farm labor hired	46	62	81	92	97
Interest expense	21	36	64	83	94

their availability would be during a catastrophic disaster, such as nuclear war. Under such a circumstance, it is hard to imagine that the normal labor force could be organized to produce crops, though surplus labor might be available for this purpose. However, the location of these farms, coupled with the difficulty in storing fruits, nuts, and vegetables, suggests that they would be of little utility to the bulk of the population in any event.

The second group of relevant farms make up about 17 percent of all farms and tend to specialize in crops such as corn, wheat, and soybeans--food already identified as crucial to emergency planning. Here, labor seems less a problem, though it is clear that these organizations are not purely "family farms." What may be an issue is the dependence of these farms on machinery, fuel, fertilizers, and pesticides. The prevalent use of these inputs, coupled with their potential unavailability, suggests that productivity could drop dramatically during an emergency that substantially disrupted the economy.

The final relevant group is composed of the smallest farms, which make up almost 80 percent of all farms. These hire relatively little labor, tend to be overmechanized, i.e., have excess machinery capacity, and are also highly dependent on such purchased inputs as fuel, fertilizer, and chemicals. Nevertheless, they produce about 15 percent of the annual production of wheat, corn, and soybeans, an amount that could be highly significant during a massive emergency.

2.4 CONCLUSION

This review has characterized the American agricultural sector as heterogeneous and highly productive; participating heavily in foreign markets as a food supplier; independent of foreign imports for all but exotic foods; and highly industrialized, with specialized requirements for fuels, fertilizers, and pesticides. Though we have not discussed the matter in detail, the sector is also intricately involved with agencies of government, primarily the USDA, for a range of assistance that includes price supports, acreage agreements, research and development support, and even daily advice through a highly organized system of extension services and land grant colleges.

To the questions posited earlier regarding foreign dependence, flexibility, and vulnerability, we can suggest tentative answers to be buttressed in the chapters that follow. First, it is unlikely that the United States is or will be in danger of "importing" a food emergency. We are not dependent on foreign sources for any necessity, though some may have come to view such imports as seafoods, fruits, coffees, and teas as near necessities. The opportunity to look to foreign sources in the event of a domestic food crisis is also questionable. For example, a disaster befalling the United States could similarly affect Canada, the most likely source of foreign food supplies during normal times. Unaffected nations could find demands for their agricultural products multiplied several-fold. On the other hand, a domestic food crisis would be shared by our agricultural trading partners.

The question regarding the degree of flexibility that farms have to change their mode of operation if an emergency disrupts normal operations

will be addressed in succeeding chapters. However, a casual review of information presented here suggests that this capacity probably differs by crop, size of farm, and location, though in each case, the capacity to produce following a disruptive emergency is probably much less now than it was a few decades ago and is decreasing. The most likely candidates for flexibility are the small- to medium-sized farms, which, surprisingly, produce a substantial fraction of corn, wheat, and soybeans. However, even these farms are probably less flexible than is commonly believed.

Finally, a number of characteristics reduce the vulnerability of the sector. Foremost is its incredible productivity, which has resulted in the accumulation of substantial surpluses for many commodities and the use of many crops for animal feed. The major question here is the impact of flexibility on surpluses. If there are no threshold effects, such as a massive dependence on pesticides or fertilizers, the productivity of the sector imbues it with enormous resiliency.

3. INSTITUTIONAL CONSIDERATIONS

3.1 INTRODUCTION

This chapter summarizes literature on institutional considerations: the participants, framework, functions, activities, and related aspects of responses to food supply emergencies. Studies and publications that identify and organize information on institutions dealing with all food supply phases in disasters are considered (Oliver 1982, Sullivan 1979, USDA 1977a and 1983). As discussed in Chapter 1, most disasters that disrupt food supplies are marginal in national effect (Patak 1964, Rogers 1984, Ruffner 1977), but may nonetheless vary considerably in terms of spatial impact, severity of damages, and location. Most of the studies reviewed support this conclusion, stating that the highly developed but dispersed agricultural sector and activities in the United States [including production, processing, transportation, and distribution of agricultural products, together with relatively high, on-going levels of production (and even overproduction) in some commodities, and very large inventories of agricultural products] render the impacts of most potential disasters on the nation's food supply quite small except in cases of extremely severe disasters, such as a nuclear attack or a severe earthquake (Oliver 1982). This is because, for less than massive disasters, it is always possible to import foodstuffs from another region or to use the abundant inventories that characterize the food system during normal times.

The literature on this subject concludes that, for a disaster to impact the nation's food supply significantly, an emergency must affect a

large, multistate geographic area and must destroy or severely damage critical sectors of the economy, including transportation, energy production, and food processing (Sullivan 1979, USDA 1977a). In other words, the emergency must sever supply lines. For an emergency to continue, the disaster must explicitly impair the agricultural sector in a way that significantly affects the production of an agricultural season (Oliver 1982, Sullivan 1979). Disasters that are less severe may create local and/or regional crises in food supply or may result in national shortages of particular food products. These difficulties, however, cannot be regarded as a national food supply crisis because, in general, they can be overcome by slight redistribution of other food products (Becker 1984, Blanchard 1982, Oliver 1982).

For example, as shown in Table 1.1, even emergencies of significant severity, such as those resulting from tornadoes or major hurricanes, have very limited impacts on the U.S. food supply. Such disasters may result in hardship and injury and may disrupt aspects of production, processing, transportation, and distribution in the areas where the disaster takes place. However, the very limited impact of such emergencies on the food supply is apparent from the swiftness with which temporary food shortages are eliminated (Douty 1972, FEMA 1983, Phoenix 1980, Quarantelli 1982).

A large and diverse number of institutions--governmental, quasi-governmental, private, and religious--offer aid and relief to the populations affected by disasters and are responsible for the swiftness with which temporary food shortages are eliminated (ARC 1982, FEMA 1980b, 1981, USDA 1983). Studies that review these institutions fall into two

broad categories: (1) those which analyze institutional issues related to emergencies that occur frequently and therefore have a historical record (tornadoes, hurricanes, floods); (2) and those which cover the institutional issues that would surface in the event of a nuclear attack on the United States (and, to a lesser extent, other very large scale disasters). The analytical coverage for the first category is based on historical data bases and analyses [American Red Cross (ARC) operations reports, FEMA 1983, United Research 1984]. The analyses undertaken for the second category are prescriptive in nature and are intended to support national preparedness (Billheimer et al. 1978; FEMA 1980b, 1983a, 1985b; Sullivan 1979).

The most striking characteristics of the frequent, limited-impact emergencies in the United States are the number and diversity of institutions that respond and perform various mitigating functions, including emergency food supply, when such emergencies arise (FEMA 1980b, 1981; USDA 1983). Responses to the very smallest emergencies at the local level are likely to be managed by local elected officials and appointees, including the fire chief, police chief, and perhaps an emergency preparedness or civil defense officer. An example of a small, localized disaster is an isolated tornado that destroys residential areas and perhaps the town's only grocery store. Food assistance may initially take the form of cold or hot prepared food served on the scene or in temporary shelters. If extended temporary shelter is required, the food assistance may be provided by the facility through which the temporary shelter is arranged. The Red Cross usually determines such needs and arranges temporary (short-term) solutions at no cost to recipients.

Customarily, if a disaster involves Red Cross response, other organizations will look to the Red Cross to assume the lead role in providing or coordinating immediate food and shelter assistance.

Requests for assistance beyond the local level go from the local government to the state Emergency Services Office, Civil Defense Office, or a similar agency. Claims for federal assistance are sent to the regional FEMA office through the state agency designated by the governor. Through this progression, the Red Cross and other organizations involved in the emergency provision of food obtain access to the nearest food resources as needed. Ultimately, a Presidential declaration of a national disaster may be required.

The number of such declarations may be quite large. For example, in 1984, the President made 38 such declarations. This meant that, in addition to the numerous local and state organizations and institutions that responded, federal agencies, including FEMA, provided assistance (FEMA Public Information Office). The estimated average number of various institutions responding to an emergency of this sort is over 20; however, the putative nature of this estimate should be emphasized. No census of lesser disasters with local food supply implications is maintained, though the frequency of natural disasters suggests that the number may be relatively large, with many institutions providing assistance (Patak 1964, Ruffner 1977).

A good example of the number and type of institutions that may respond to these limited emergencies can be seen in Table 3.1, which lists resources and services of various volunteer organizations active in a disaster. Table 3.1 shows that, during a limited emergency, over 20

TABLE 3.1 INSTITUTIONS RESPONDING TO LIMITED EMERGENCIES

RESOURCES AND SERVICES OF VOLUNTEER ORGANIZATIONS ACTIVE IN DISASTER	Professional Staff	Trained Staff	Trained Volunteers	Untrained Staff	Untrained Volunteers	Facilities for Stationary Feeding Equipment for Mobile Feeding	Mass Shelter Facilities	Trucks	Vans	Buses	Station Wagons	Rescue Equipment	Communication Equipment	Clothing	Bedding	Used Furniture	Materials for Rebuilding Homes	Collection and Distrib. of Donated Goods Other than Clothing	Collection, Sorting, Storing of Used Clothing	Cleaning Debris from Privets Prop.	Cleaning Homes	Free Labor to Repair or Rebuild Homes	Welfare Inquiry Service	Registration and Information Service	Counseling Service	Capability to Handle Crisis Interven. and Long-term Recovery	Training	Financial Assistance	Comments
The American National Red Cross	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					x	x	x			x	x	A
Ananda Marga (AMURT)	x	x	x	x										x	x	x		x	x					x	x				
Boy Scouts of America	x	x	x	x	x	x	x	x	x	x	x																		
B'nai B'rith	x				x															x	x	x							
Christian Reformed World Relief	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	B
Church of the Brethren	x	x	x	x	x	x														x	x	x	x						B
Church World Service	x	x	x											x	x														
Goodwill Industries	x	x	x	x				x	x			x	x	x															
Lutheran Council in the U.S.A.	x			x	x	x							x	x									x	x	x	x		x	
Mennonite Disaster Service	x	x	x																	x	x	x							B
National Catholic Disaster Relief Com.	x	x	x	x	x	x								x	x	x									x	x			
National Catholic Conference and Catholic Charities	x	x	x	x	x	x								x	x	x									x	x			
Presbyterian Church U.S.A.	x	x	x	x	x	x				x	x	x	x	x	x	x	x	x			x	x	x	x	x	x			
The Salvation Army	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x	x	x	x	x	x	C
Seventh-day Adventists	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	D
Society of St. Vincent De Paul	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	F
Southern Baptist Convention	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	E
United Methodist Church (UMCOR)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	
United Presbyterian U.S.A.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	
Volunteers of America	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	G
The Episcopal Church	x	x																											

Note: A - Congressional mandate. If no other resource, Red Cross will meet needs. B - Expertise in establishing interfaith organization. C - Bulk food distribution; warehousing ready supplies. D - Private mobile homes available for major disasters. E - \$100,000 revolving fund and more if needed. F - May be only in one or a few larger councils. G - Ambulances and air transportation and rescue.

organizations (mostly religious in character) may be active in providing emergency response functions by offering over 20 different types of services, including emergency food supply (ARC 1982 and parallel documents; FEMA 1980b, 1981). Most of the services rendered are provided on a voluntary basis (from Red Cross operation reports and memoranda of understanding), though some of the activities undertaken and services rendered by public and private institutions are required by existing federal and state regulations (ARC 1982, FEMA 1985, National Association of Counties 1982, USDA 1983).

The experience gained by these institutions in providing services during and after limited emergencies may not, however, be readily transferable to very large scale emergencies such as nuclear attacks (FEMA 1985, Sullivan 1979, USDA 1983). On the one hand, the training provided by the lesser disasters establishes a core of professional and experienced personnel with some expertise in providing certain assistance to the population, including assistance in emergency food supply. These core personnel may be very important in the event of a major disaster if used as supplementary personnel for such agencies as the USDA (Billheimer and Simpson 1979, FEMA 1984). On the other hand, the personnel are primarily volunteers who often view their service time as a diversion from their normal activities. Under a widespread emergency, many would undoubtedly have personal matters in need of attention.

The remainder of this section discusses the institutions involved in emergency food services. Foremost are the USDA, FEMA, and a set of private institutions of which the most notable is the American Red Cross. These leading players are supported by other agencies of government with

particular specialties, such as Health and Human Services (HHS October 1985) and the Department of Transportation.

3.2 U.S. DEPARTMENT OF AGRICULTURE

The role that is assigned to the USDA in major disasters is well established and documented and has been subjected to numerous USDA directives, advisories, circulars, and related publications (USDA 1983). A series of Defense Food Orders, developed with industry assistance and updated in 1976, describes USDA responsibilities. In broad terms, the USDA is responsible for preparing national emergency plans and developing preparedness programs relating to (1) food production, processing, storage, and distribution through the wholesale level, and farm equipment, fertilizer, livestock and poultry feed, and seed for planting essential crops; (2) lands under jurisdiction of the Secretary of Agriculture; (3) rural fire control; (4) defense against hazardous agents (nuclear, biological, and chemical) and attack effects pertaining to agricultural production; (5) water for use in agricultural production and food processing; and (6) rural defense information and education (USDA 1980a, 1983). For many of these activities, USDA has prepared formal plans. For example, Standby Defense Orders 1-6 describe how USDA would deal with appeals, food, seed, feed, fertilizer, and farm equipment, respectively.

The USDA's dominant presence in emergency situations with respect to food supply can be described best by extracts from the USDA circular 1800.1 (USDA 1983). This regulation identifies the defense emergency and national disaster responsibilities of the USDA and the organizations for

carrying them out at the national, regional, state, and local levels. The responsibilities include the procurement of food for emergency use and the provision of disaster assistance through regular USDA programs.

Some of the authorities under which USDA can prepare for and respond to a defense or natural disaster situation are the National Security Act of 1947; the Defense Production Act of 1950, as amended (50 U.S.C. App. 2061 et seq.); Federal Civil Defense Act of 1950, as amended (50 U.S.C. App. 2251 et seq.); Executive Order 11490, as amended; Flood control Act of 1950; Disaster Relief Act of 1974, as amended; the Commodity Credit Corporation Charter Act; and the Strategic and Critical Materials Stockpiling Act (50 U.S.C. 98 et seq.).

USDA responses are handled by key personnel in a nationwide emergency organization formed to use the Department's peacetime capability for emergency tasks. (See Fig. 3.1 for summary organization chart.) The breakdown is as follows:

- At the national level the Director, Intergovernmental Affairs (IA), coordinates USDA emergency programs. IA serves as the central contact within the Department and works closely with offices of other departments and agencies. Each USDA agency that has a responsibility designates an Emergency Program Contact to work with IA and advise the agency leadership on readiness matters.
- At the regional level, the Regional Emergency Staff (RES) in each of the ten Standard Federal Regions assist in carrying out USDA defense responsibilities at the regional level. The RES chairperson may be called upon to coordinate USDA response to natural disasters, although the staff is activated for defense purposes only. There are six Category A agencies on the RES. When the staff is activated, agency personnel on the RES operate as USDA, rather than agency, personnel.
- At the state level, coordination of USDA emergency programs is handled by the USDA state Food and Agricultural Councils (FACs).
- At the local level, coordination of USDA emergency programs is handled by the USDA and the local FAC. Membership consists of a

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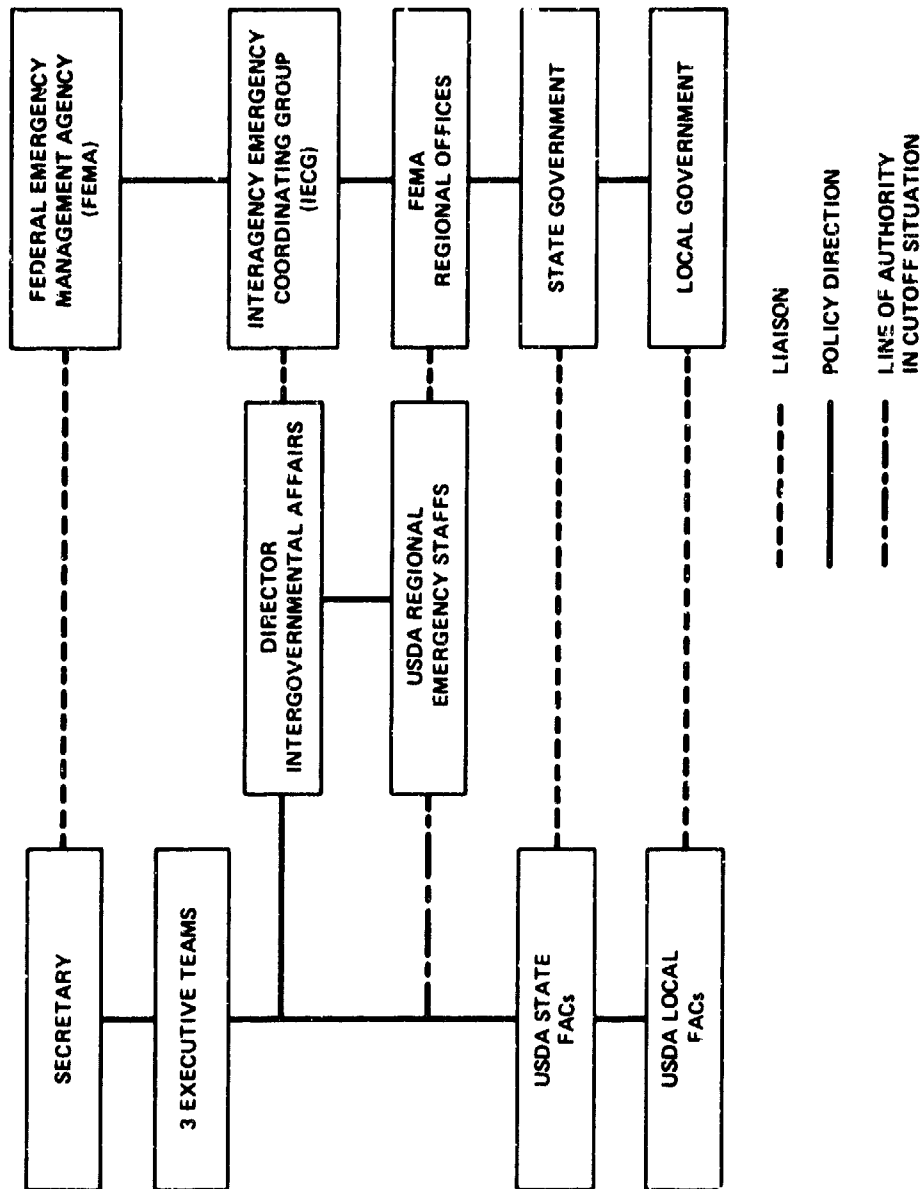


Fig. 3.1. USDA emergency organization.

representative of each USDA agency having available personnel at the local level.

Overall, the USDA, under the direction of the Secretary of Agriculture, is responsible for executing a wide range of emergency programs related to food supply in the cases of large-scale and limited emergencies. With respect to national defense, the USDA may become involved in preattack activities as well as transattack and postattack pertaining to:

- Food resources, seed, livestock and poultry feed, fertilizer, farm equipment, and food resource facilities.
- Lands under the jurisdiction of the Secretary of Agriculture.
- Rural fire control.
- Defense against hazardous agents (nuclear, biological, and chemical), and effects pertaining to agricultural and forestry activities.
- Rural information and education.
- Water to be used in agricultural production and food processing.

In the event of a natural disaster, the USDA may undertake the following functions:

- Provide emergency food coupon assistance in disaster areas.
- Donate commodities to disaster relief agencies for group feeding and emergency household distribution in areas served by the food stamp program.
- Assist in providing livestock feed.
- Provide loans and cost-share financing to assist farmers and other rural residents in rehabilitation efforts and to assist rural electric and telephone cooperatives and companies to repair or replace damaged lines.
- Make payments to farmers for crops covered by insurance through the FCIC.
- Assist farmers and others to develop disaster recovery plans.
- Control plant and livestock diseases and insect infestations.

- Provide fire protection on or adjacent to National Forests and assist in the suppression of fires in other rural areas.
- Provide disaster assistance through regular USDA programs.
- Assure the purity and wholesomeness of meat, poultry, eggs, and egg products.
- Procure food for emergency use.

The USDA has organized emergency food supply assistance programs utilizing existing offices of the Department (USDA 1983). Most, if not all, of the USDA offices have been assigned specific functions to provide emergency food supply services in the event of limited as well as large-scale emergencies (see Table 3.2) which are also related to the normal (nonemergency) operating charters of the respective offices. It appears that USDA will assume major responsibilities for all phases of the food system up to, but not including, food distribution in the event of an emergency.

The pertinent documents show that a wide variety of USDA agencies will come into action in the event of limited or major disasters, natural or man-made. For example, the Soil Conservation Service has the mandate to provide technical assistance in the event of drought. Following a nuclear attack, the Soil Conservation Service would be responsible for identifying crops to be grown on radiologically contaminated land.

Another example of the USDA emergency activities performed during limited as well as major emergencies can be seen from the Agricultural Research Service functions. This agency is responsible for providing certain technical assistance in limited emergencies such as floods. However, during a nuclear attack this agency is required to undertake a

Table 3.2. USDA offices with emergency food supply responsibilities

Agricultural Stabilization and Conservation Service
Commodity Credit Corporation
Forage Agricultural Service
Farmers Home Administration
Federal Crop Insurance Corporation
Rural Electrification Administration
Agricultural Marketing Service
Animal and Plant Health Inspection Service
Food Safety and Inspection Service
Office of Transportation
Economic Research Service
Office of Energy
Statistical Reporting Service
Forest Service
Soil Conservation Service
Food and Nutrition Service
Human Nutrition Service
Agricultural Research Service
Cooperative State Research Service
Extension Service

number of activities directly related to radioactive impact on food supply, including:

- Develop guidance on the effects of radiation on agriculture.
- Provide guidance on the most efficient procedures for producing, processing, storing, and distributing agricultural commodities under postattack conditions.
- Coordinate the administrative functions on behalf of the Secretary for radiological safety within the Department.

The active role that USDA agencies play in providing emergency food assistance during limited emergencies provides these agencies with experience and in-house training to render assistance in the event of large-scale emergencies (USDA 1983).

The literature also emphasizes the fact that the USDA, in providing its food assistance during various emergencies, prescribes close cooperation between the USDA and other federal, state, and local units, most of which house USDA personnel or staff (USDA 1983).

The continuing presence of USDA personnel at local and state offices during peacetime provides a well-established basis for the USDA to apply its emergency food supply operations using the structure and personnel of the existing offices at the state and local levels (Billheimer et al. 1978, USDA 1983). The fact that the state and local USDA offices have ongoing and well-established contacts with other federal offices at the state and local levels and first-hand experience and familiarity with local socioeconomic and other conditions provides additional capability and expertise on the part of the USDA local offices in providing local, regional, and national emergency food supply assistance in the event of major national emergencies.

Further, because USDA personnel and offices are regularly involved with the available food supply and food demand at local, regional, and national levels as well as with the factors of agricultural production to produce, process, and transport food supplies, USDA agencies and personnel are well trained to analyze and determine the critical allocation of factors of production and render other related services for food production as opposed to immediate supply from existing inventories during national emergencies (Billheimer and Simpson 1979, FEMA 1985).

In summary, most of the literature concludes or implies that the USDA is possessed of intimate knowledge of all phases of the food system and has prepared detailed plans to govern its activities during emergencies. Clearly, no other agency possesses its expertise. It is equally clear that for marginal departures from normal conditions, USDA is well prepared. It is, however, not expert in emergencies in general and disasters such as nuclear war in particular. In these instances, USDA would draw heavily upon the expertise of FEMA.

3.3 THE FEDERAL EMERGENCY MANAGEMENT AGENCY

The role of FEMA in providing food supply in the event of a major emergency is conceptually clear. FEMA is to provide coordination among various agencies at federal, state, and local levels, as well as among private and quasi-private organizations, and to serve generally as an expert consultant, particularly to the President and the executive branch, in the exigencies of a wide range of emergencies, including nuclear war (FEMA 1980b, 1984a, 1985b).

Thus, FEMA's role is one of adjudicator and coordinator, as well as the prime contact for those in need of federal resources in times of emergency. Its role is to provide leadership and assure coordination among various federal agencies, as well as among state and local agencies and quasi-private groups. This role can be seen readily from the following citations from pertinent documents.

The U.S. Government Manual (USGPO 1982-1983) describes FEMA's mission as follows:

The Federal Emergency Management Agency (FEMA) was created to provide a single point of accountability for all Federal emergency preparedness, mitigation and response activities. The Agency is chartered to enhance the multiple use of emergency preparedness and response resources at the Federal, State, and local levels of government preparing for and responding to the full range of emergencies--natural, man-made, and nuclear--and to integrate into a comprehensive framework activities concerned with hazard mitigation, preparedness planning, relief operations, and recovery assistance.

The FEMA interface with state and local governments, volunteer organizations, and other private sector organizations is outlined in the following extracts from FEMA 57/May 1984:

Interfaces with State and Local Governments

The routine communications between and among FEMA headquarters and state and local governments are usually channeled through the ten FEMA Federal Regional Offices and follow the usual federal-state-local organizational hierarchy. Under special circumstances and emergency conditions, however, that routinized channel may be modified or redirected. For example, in fulfilling its mandate from Congress as coordinator of The National Earthquake Hazard Reduction Program, FEMA enters into cooperative partnership agreements with states and localities to develop long-term earthquake mitigation and preparedness measures. Thus, the FEMA-sponsored Southern California Earthquake Preparedness Project (SCEPP) involves a partnership between and among FEMA Headquarters, FEMA Regional Center IX, and the California Seismic Safety Commission. The partnership also includes the

California State Office of Emergency Services, various other elements of the California State Government, and representatives of the principal Southern California communities and relevant private sector organizations. Moreover, under actual disaster and emergency conditions the usual chain of direction and control may be temporarily bypassed by direct contacts between the EICC/AEICC and local emergency operations centers (EOCs) or by the appointment of a FEMA Federal Coordinating Officer, who, working with a State Coordinating Officer, administers federal assistance to a local disaster-struck area.

Interfaces with Voluntary Organizations

The United States is characterized by a vast proliferation of voluntary organizations in virtually every field of human interest. The field of disasters and emergencies is no exception. From the early days of the republic to the present, voluntary disaster relief and assistance agencies have played a significant role in post-disaster response and recovery. Public Law 93-288, the Disaster Relief Act of 1974, officially recognizes three voluntary relief agencies by name--the American National Red Cross, the Salvation Army, and the Mennonite Disaster Service--as ones that agree to work under the coordination of the FEMA established Federal Coordinating Officer in Presidentially declared major disasters. But many other voluntary organizations become involved in various aspects of emergency mitigation, preparedness, response and recovery. In disaster response and recovery functions, for example, there are 21 different groups involved in the umbrella organization known as the National Organizations of Voluntary Agencies Active in Disaster (NOVAD). In addition to the three relief agencies already mentioned, FEMA's Individual Assistance Division, Office of Disaster Assistance Programs, has contact with such other NOVAD members as the Boy Scouts of America, Church World Service, Goodwill Industries, the Lutheran Convention of the USA, the National Conference of Catholic Charities, the Seventh Day Adventist General Conference, the Southern Baptist Convention, the United Methodist Church Committee on Relief, and the Volunteers of America. The efforts of these national-level organizations are augmented by the work of their local chapters and a large number of other local charitable groups that become involved in post-disaster relief and recovery. In every major disaster, the Federal Coordinating Officer deals with these local voluntary agencies during the operation of the FEMA-established Disaster Assistance Centers.

Interfaces with Other Private Sector Organizations

FEMA's many responsibilities for civil defense, emergency mobilization, and disaster assistance inevitably bring the agency into contact with a vast number of different organizations in the private sector of U.S. society. The Agency as a whole has frequent contact with professional emergency management organizations, e.g., the National Emergency Management Association and the National Coordinating Council on Emergency Management (NCEM). It works with the principal public interest groups representing national, state, local government officials--e.g., the National Governor's Association, the International City Manager's Association, the U.S. Conference of Mayors, the National League of Cities, and the Council of State Governments.

Each of FEMA's program areas tends to have its own set of contacts with relevant private sector organizations. For example, in the health resources area, National Preparedness Programs, there are frequent communications with such organizations as the American Medical Association, the American College of Emergency Physicians, the American Hospital Association, American Pharmaceutical Manufacturing Association, and various medical colleges. FEMA's Office of Civil Preparedness, National Preparedness Programs, has contacts, among many others, with the American Association for Industrial Security, the Association of Plant Engineers, the American Public Works Association, the Construction Sciences Research Foundation, and the Chemical Manufacturers Association.

Many of FEMA's contacts with private sector organizations are of an ad hoc nature for limited action or information exchange purposes and the relationship is not formalized by a memorandum of understanding or other formal agreement. In other instances, however, the frequency of information exchange or the importance of the private sector organization to FEMA plans, programs, and operations may dictate a more formal, continuing relationship and the establishment of special or permanent communication and data links.

Various reports and publications have documented FEMA's skillful performance in assuring emergency food supply in limited emergencies (United Research 1984, Becker 1984, Billheimer 1985). However, some of the literature implicitly acknowledges that FEMA's role as food supply coordinator in the event of large emergencies such as nuclear attack or

catastrophic earthquakes may be somewhat difficult because FEMA personnel have no significant actual experience in coordinating such an effort (Brown 1969, FEMA 1980b, 1985, Sullivan 1979, USDA 1977a, 1983). Moreover, while FEMA possesses the necessary expertise in emergencies and preparedness, there is very little evidence that it has developed formal internal plans that parallel those of the USDA. Furthermore, whereas the USDA emergency food supply activities will be undertaken largely by the personnel of that agency within an existing infrastructure, the coordinating activities of FEMA will necessarily involve personnel from numerous other agencies who may have conflicting operational modes and other differences (FEMA 1984a, 1985b). To carry out its mission successfully, FEMA must identify counterparts in USDA and other agencies and anticipate and resolve conflicts in advance.

3.4 STATE AND LOCAL GOVERNMENTS

The roles of state and local agencies in providing emergency food supply essentially parallel those of the USDA organization. The emergency food supply role of local agricultural agencies is described as a closely integrated extension of the USDA and FEMA, with state and local agencies supporting the USDA and FEMA offices with the necessary personnel and other resources to distribute emergency food supplies (Billheimer and Simpson 1979; USDA 1977, 1983). The available literature on the role of state and local governmental organizations in providing emergency food supplies suggests, however, that there may be significant differences in the abilities of the various local jurisdictions and states to render such services. These differences depend on factors such

as the extent of planning for emergency management in general and emergency food supplies in particular; commitment by the state and local government officials; and agreements regarding coordination among federal, state and local offices and related factors (National Association of Counties 1982, United Research 1984).

3.5 NON-GOVERNMENT INSTITUTIONS

The role of private organizations in emergency food supply in major national emergencies is relatively limited in comparison with their role in lesser emergencies. This limitation results from several factors.

One limiting factor is that most of the private institutions which provide emergency feeding have few, if any, full-time personnel. Most of these organizations are staffed by volunteers who may be able to offer services under emergency conditions but who are not well prepared to do so in the event of large emergencies, where their own lives may be threatened (United Research 1984). The second characteristic that renders private institutions less useful in providing emergency services during severe national emergencies is their lack of training and expertise in this area (Dresch and Ellis 1974). The third characteristic limiting the role of such private organizations is that their experience is restricted to emergency food supply situations involving much smaller spatial and functional dimensions. Thus, voluntary organizations, which are so very well equipped to provide food supply services in conventional emergencies, may be of lesser value in providing such services during major emergencies (Dresch and Ellis 1974, FEMA 1980b, Friesema 1979, Greene et al. 1979, Katz 1982, McMasters 1978).

There may be exceptions to this conclusion. For example, the various emergency services provided by the Red Cross are based on well-established experience; this organization is at the forefront in providing services, including food supply, in emergencies of most types (ARC 1982). However, even the Red Cross is reluctant to commit itself to providing emergency services in the event of nuclear attack. This may be a gap in current planning. USDA publications generally describe its role as ending at the wholesale level--i.e., it delivers food but does not distribute it. An older publication describes the former Department of Health, Education, and Welfare as responsible for welfare services, including feeding (DOD 1966); but no mention is made in the most recent Health and Human Services emergency services plan (HHS 1985). While there are clearly a number of candidates to fill this apparent gap (e.g., state emergency offices and the national guard), FEMA should investigate this matter further.

As noted in some reports, the role of private organizations in large-scale national emergencies could be enlarged by appropriate training and by concentrating their efforts in several areas that are more amenable to the characteristics of these private organizations. Such areas include, for example, providing and distributing food supplies after a critical elapsed time period immediately following an emergency, ensuring food supply services in areas not directly impacted by an emergency, and providing supplementary food supply services to organizations such as the USDA and FEMA (Anderson 1969, Earle 1980, FEMA 1985b, USDA 1977).

3.6 CONCLUSIONS

In summary, the literature on institutional considerations with regard to emergency food provision indicates that the USDA, because of its well-established local presence, experience, and expertise, must play a key role in the event of a major national emergency in providing food supplies, distributing these supplies, and providing guidance and direction toward production of additional food supplies. Several other federal government departments, such as the U.S. Department of Transportation and the Department of Health and Human Services, will play important but subordinate roles in providing food supply in the event of a national emergency.

Two major questions arise from this institutional review. First, although the USDA possesses a vast body of expertise regarding the normally operating food system, the department is not generally oriented to severe emergencies. Whether the USDA is prepared to step outside its normal experience--for example, in relaxing standards of wholesomeness in foods, in destroying livestock to reduce demands on foodstocks, or in other radical departures from business as usual--is not clear. In contrast, FEMA should be prepared to meet such a situation, given its focus on departures from normalcy. Its readiness to do so forms the essence of the second question that the review raises. While FEMA has acquired a familiarity with disasters, it has not prepared plans that parallel those of USDA and other agencies. It is, therefore, not clear from this review precisely how, or if, FEMA could exercise its delegated responsibility.

4. SHORT-TERM COPING ACTIVITIES FOR NATIONAL FOOD EMERGENCIES

4.1 INTRODUCTION

There are virtually as many potential time frames for emergency food mitigation actions as individual circumstances that may arise. For the present analysis, however, we have chosen to make two broad divisions--short term and long term. Byrne and Bell (1971), Cuny (1979), Haaland (1977), Shinn (1968), and U.S. DOD (1966) discuss this issue. The availability of food from current stocks is the primary distinction between the two divisions: short-term actions include those activities concerned primarily with the allocation and use of existing food stores; long-term actions focus on restoration of business-as-usual conditions, in particular the resumption of farming and agricultural enterprise. Nevertheless, in several instances, there are unavoidable overlaps.

A further distinction is often made in the literature between activities of different short-term time dimensions (Dresch and Ellis 1974, Bensen and Sparrow 1971, Greene et al. 1979, Kentucky 1983, U.S. DOD 1966). Three time frames--preincident, transincident, and postincident--are sometimes identified (Blanchard 1982). Certain pre-event actions are available in anticipation of a disaster--for example, moving food stores in anticipation of international conflict. Other actions are potentially available during an emergency, though, in practice, much of the literature treats the event itself as a point in time. This is clearly incorrect, particularly in the case of a nuclear exchange, which could conceivably unfold over a period of weeks or even

months. Also, there are postincident actions, which sometimes overlap with long-term actions, using our definitions.

Other authors prefer to consider only two short-term time frames, immediate and short-term, with the distinction being that immediate actions are taken to prevent near-term starvation, while short-term actions are concerned with the organization of supply lines to provide an orderly distribution of existing food stocks. Examples of this second category are prioritizing the delivery of warehoused products (Billheimer and McNally 1980) and using grain reserves (Garland 1972). This framework devolves from the more traditional emergency literature, which assumes an event and then a recovery. Because each has some advantages, we shall consider four periods--preincident, transincident, immediate, and near-term.

The approach taken here is to consider the components of food supply identified in Chapter 2, remembering that for each time phase, actions taken to cope with the emergency will deal with different components. The focus is generally on wide-scale events because only they are of sufficient consequence to involve FEMA. This means that most literature cited deals largely with civil defense and postattack recovery. Before turning to these topics, it is useful to review two broad-based assumptions that pervade much of the literature.

The first is that food demands following an emergency, particularly a nuclear conflict, would differ from those existing before the emergency. This occurs for two principal reasons. First, people would move in response to a disaster or an impending disaster--for example, by evacuating cities in anticipation of nuclear conflict. While this

phenomenon is well documented (Sorensen 1985), the recent declaration by FEMA that federal policy no longer includes a planned evacuation causes greater difficulty in anticipating the location of changes in demand. Examples are given in Advance Research (1965b), Sullivan (1979), and USDA (1977a). A second, generally unstated assumption is that not all of the population would survive the conflict. Estimates of casualty rates, though not always classified, rarely appear in unclassified official literature. Such estimates are highly dependent on scenario assumptions about attack and defense postures.

The second assumption is that food resources would generally be sufficient to meet the needs of the population. Garland (1972), for example, supported this view in examining a detailed food reserve strategy, currently being updated by Kerley and Das (1985). Haaland (1977), in a follow-up study, set out to prove the feasibility of moving food from place of storage to the population, in terms of available fuel, rolling stock, etc. He also reports in the affirmative. Unfortunately, the Haaland paper does not address the difficult issues of how to accomplish the rather intricate series of transfers deemed necessary.

Finally, the reader is reminded that here, as in the case of much of the civil defense literature, the papers reviewed are often quite dated. It has generally not been possible to assess fully the impacts of age on this body of information.

4.2 PRE-EVENT ACTIONS

Pre-event actions deal largely with the difficulties that would be encountered in attempting to feed an evacuated population that, in

anticipation of a nuclear conflict, has left cities and is residing in temporary facilities in relatively rural areas. In principle, these actions could be applied to any large-scale disaster; in practice, it is hard to find a practical example of other disasters of sufficient scope to justify widespread evacuation.

This topic was addressed in detail by John W. Billheimer and Janet McNally in a 1980 publication that followed a two decade series of reports by Billheimer (see bibliography) dealing with feeding issues in anticipation of, and following, a nuclear exchange. The basic issue in this case is what approach to follow, given that during normal times the food system is directed at cities rather than rural areas. Billheimer outlines a strategy based on using the private sector to deliver a modified set of food products through normal channels, except that large chainstores in cities no longer serve as primary distributors to consumers. Instead, these same chains redirect food shipments to their rural branches. Billheimer estimates that a 4- to 6-week supply of food resides in various components of the food chain. This amount is probably sufficient for the preattack period (Blanchard 1982). The report draws upon a rather extensive body of study to prepare guidelines that

- chart basic wholesale/retail food distribution patterns throughout the country;
- outline basic guidance for the food industry under crisis relocation conditions;
- contain step-by-step procedures for reallocating food supplies;
- supply the basic data necessary to plan for food redistribution;
- provide examples of the use of the redistribution procedures in nine

FEMA regions; and

- recommend steps designed to coordinate planning levels at the federal, regional, state, and industry levels.

This series of studies is impressive in its attention to detail and its focus on practical matters. The degree to which it is feasible is not known. In particular, the plans outlined require a great deal of coordination and rely on information that could become rapidly dated. They should be made the central focus of an evaluation exercise, if they have not yet been so, to evaluate their practical applicability.

4.3 TRANSINCIDENT COPING ACTIONS

During the 1960s, the United States supported a widespread campaign to provide stockpiles of food for consumption during a transattack period, under the Federal Civil Defense Act of 1950 (Blanchard 1982). At that time, a good deal of research addressed such issues as appropriate food quantities, qualities, shelf-lives, etc. For example, Chow (1969), Calloway (1960), and the National Research Council (1963) discuss the nutritional content of potential shelter rations. Cecil (1970) discusses the expected shelf life of rations, and Reen et al. (1963) discuss potential practical difficulties of living in a shelter. Unfortunately, most of these rations are no longer considered a viable source of nutrition, having long since passed their expected life of five years, though some speculate that some nutritional content may remain in them (Blanchard 1982).

In all, the literature in this area appears to provide an adequate base for the development of a transattack sheltered food program;

however, current government policy does not provide rations for this purpose (FEMA 1983d). Were this policy to be reinstated, there would undoubtedly be a need to re-examine the literature on food preservation to include recent developments.

An alternative to publicly provided food during this period would be privately provided stores, as has been espoused by various "survivalist" groups (Oster 1984, 1985) and some religious bodies (Dickey 1969). Most authors dealing with individual survival have some mention of food. Kearney (1979) provides perhaps the most authoritative suggestions and strategies for surviving in a transattack environment, though many of his suggestions assume preparations that have not been undertaken by the typical family. In general, there is a small but adequate number of "official" reference documents available for food planning. One USDA (1977c) publication and one FEMA (1983b) publication were identified as appropriate. A third publication was more useful for planners operating larger shelters. In general, this part of the emergency food literature can be criticized because of its sparseness. Whereas many official technical reports have been prepared which are designed to support planning efforts, they have rarely been compiled into a form that is easily usable, even though de facto policy is to rely on individuals to provide their own stores. The family wishing to make such plans must therefore rely heavily upon privately prepared literature, much of which may be excellent, but which on the whole has not been subject to the review process required of a government report. FEMA should review this general area and consider supplementary documents.

4.4 IMMEDIATE COPING ACTIVITIES

The two principal areas in providing adequate food supply to the population which require immediate action following a national emergency are transportation and distribution of processed food products (ARC 1982, Hall and Hamberg 1970, Oliver 1982). Damage to foodstuffs and to transport facilities are the primary impediments to addressing immediate feeding needs successfully (Brown 1973, FEMA 1985). In instances where foodstuffs from outside the damaged area are readily available and can be transported with little or no difficulty, the institutions (such as the American Red Cross) described in Chapter 3 can generally deliver food.

The first issue in an immediate feeding campaign is assessing food needs. As was discussed previously, the location of the population following a major disaster, such as nuclear attack, may be quite different from that during normal times. This difference causes both strategic and tactical difficulties. Before transporting food, one must know where to direct it. Having made the determination of destination, one must obtain the necessary resources to move food from origin to destination and initiate the process of doing so.

A variety of methods have been used to estimate postattack populations. The basic unclassified source for population evacuation has traditionally been an unpublished FEMA document giving host area population under alternative assumptions about evacuation rates. Some studies reduce this by a damage assessment analysis (Haaland et al. 1976), while others merely make alternative assumptions about survival rates (Billheimer and Simpson 1978). Billheimer (1985), Brite (1976), and Carr (1975) discuss this issue further.

Quantities of food to provide each person in the postattack environment are fairly arbitrary designations, despite the relatively broad base of knowledge about nutrition. Whereas Franz and Kearney (1979) provide a classic discussion of nutritional needs, their general recommendations probably exceed short-term food requirements. Miller and Schrimshaw (1965) suggest that an austerity diet of 1,200 to 1,500 calories per day should sustain a healthy adult for roughly 30 days. Pregnant and lactating women, small children, the infirm, and the elderly will require special diets, even during early periods. In general, consideration must be given to calories, salt, vitamins, and minerals. Because the body stores these nutrients for differing lengths of time, the number of days one can survive with different deficiencies is highly dependent upon the health of the individual, the particular foods provided, and the activities in which the individual partakes. On the whole, there is a strong scientific base for analyzing nutritional issues (Calebrese 1981, Briggs and Calloway 1979, Beaton and McHenry 1964, Franz and Kearney 1979). In the shortest term, however, if water and calories are provided, most will avoid malnutrition.

Difficulties in transporting food could be much more serious than the determination of food needs during the short term. In general, procedures for initiating food transport have been established and prescribed in appropriate planning documents (Defense Food Orders, USDA 1983). Planning issues are discussed by Bigelow and Dixon (1963), Brite and Segal (1976), and Brouillette (1970). It is assumed by most analysts that highway transportation, as compared with rail and water transport, would dominate the transport of agricultural commodities and processed

products in the immediate time period because of the relative flexibility in selecting routes, cargo size, etc. (Bigelow and Dixon 1963, Dixon and Tebben 1967, Sullivan 1979). Air and water transport of food supplies is generally not considered feasible, except under extraordinary conditions (Grain 1965, Hall 1968). Estimates of surviving truck and transport facility populations vary considerably. Sullivan (1979), for instance, estimates that only about 60 percent of Ohio's trucks would survive a nuclear attack because a disproportionate number of trucks are assumed to be in the urban areas at the time of the attack, distributing food to evacuees. In contrast, Billheimer (1978) suggests the use of "transportation stress factors," which consider a broader spectrum of characteristics such as trucks, drivers, rates of utilization, etc.

Stocks of warehousing facilities could change dramatically after a disaster as large as a nuclear attack. To the extent that much warehousing is located in high-risk areas, many facilities would be lost. In a Colorado case study, Billheimer (1978) has estimated that only five percent of Denver's wholesale warehousing space would survive. Hence, when it is necessary to move supplies into a stricken area, it may be necessary to make do with very austere facilities.

When dealing with an evacuated population, the situation is reversed. The areas hosting evacuees have never possessed high population densities and therefore have never had the facilities (Advance Research 1962, 1965; Brite and Segal 1976; Dixon and Tebben 1967; Katz 1982). Warehouse and distribution facilities of the type commonly found in major urban centers would not be present (Carr, Dresch and Ellis 1974; Haaland et al. 1976).

Warehousing problems can occur across a broad range of emergency situations. This is particularly true with refrigerated warehouses. A number of studies identify the need to mitigate potential damage to food supplies stored in damaged refrigerated warehouses or which has been moved to nonrefrigerated warehouses as an expedient measure (Katz 1982, Kentucky 1983, Sullivan 1979). An inventory of warehouses with standby power might be a useful planning tool (USDA 1977). The increasing proportion of food supplies stored and distributed frozen, combined with the potential for disruption of the electricity supply during emergencies, places priorities on activities directed toward the mitigation of this potential disruption (Advance Research 1962, Laurino 1980; Pape and Van Dress 1967).

In summary, the literature suggests that immediate attention needs to be directed toward estimates of food requirements, by location, with attention turning next to transport facilities and distribution facilities. It is assumed that sufficient institutional mechanisms exist in the short term to facilitate distribution, though it is suggested in Chapter 3 that certain traditional institutions, such as the American Red Cross, will likely be less available as the scope of the disaster broadens. Activities related to production and processing will have marginal priority in this immediate time period.

There is one exception to this generalization. In addition to activities related to emergency feeding, a number of other urgent activities will be necessary during the aftermath of a nuclear attack emergency--those associated with screening the inventory of food products for radiological damage (Bell 1967; Bresee et al. 1968; Brown 1968;

Eisele 1972). The literature covers these issues in detail, analyzing and estimating the radiological effect on food products such as meat and meat alternatives, eggs, dairy products, fruits, fats and oils, various vegetables and other products (Bensen and Sparrow 1971; Bottino 1971a,b,c; Brown and Kruzic 1970; NAS 1968; Schultz 1971; Sparrow et al. 1970).

The consensus among these studies is that radiological effects could be destructive to a large, but selective, portion of agricultural commodities and food products. The location of the inventories in relationship to the proximity of the attack would be the primary determinant of damage. Other factors influencing damage would be the degree of protection, the type of radiation products released, wind and weather conditions, and the type of food products under consideration (Bensen and Sparrow 1971, Killion 1975, Kopp 1984, Billheimer et al. 1978).

In the case of eggs and poultry products, Brown (1969) suggests that this industry's dispersion throughout the United States would limit the damage from an attack. Billheimer et al. (1978) are less optimistic, suggesting that nationally only one-half the laying hens would survive an attack. In general, eggs in inventory would be safe from contamination, while those produced after the attack could be affected by the layers' diets.

In the case of cereal and cereal products, the consensus among the published reports is again that these are relatively dispersed and would therefore tend to survive the attack. Radiation damage would likely be minimal, though crop products could be dusted with radioactive particles (Brown et al. 1968, Haaland 1977). However, the timing of an attack

could affect crop productivity. Crops are most sensitive during early growth and reproduction periods (FEMA 1982). Products stored in bins would less likely be contaminated than those stored outdoors.

The reports indicate that fruits and vegetables would tend to remain available in areas not directly subject to attack (USDA 1977a,b). Most could be cleaned of radioactive dust by washing. Of course, the availability of these products is quite dependent on the season of the year and also on the available labor force for harvesting. As was discussed, there are a variety of reasons to suspect that fruit and vegetable farms would be more easily disrupted in the short-term than grain or livestock operations.

Animals on the hoof pose a much more difficult problem than most food products, because their irradiation raises a number of questions that the available literature does not clearly address. First, the dispersion of these farms would tend to reduce the likelihood of damage due to blast and to some degree due to radiation (Bensen and Sparrow 1971, Byrne and Bell 1971). A number of studies have examined the effects of radiation on animals (Bell and Cole 1967, Brown et al. 1968, Eisele 1972, Eisele and West 1973, Eisele and Bell 1973). However, a number of questions remain unanswered. Should one butcher animals that are ill from radiation at first sign of illness or should one wait? If one does slaughter an animal, what parts can be eaten and what should be discarded? How should the meat be prepared? If butchered, how should the meat be stored? These questions overlap with the long-term agricultural issues of how much feed should be devoted to animals if humans experience shortages? Because of the heavy dependence of the

American consumer on beef and pork, it might be assumed that most people would be biased toward the consumption of animals. The issue is raised as an example of a potential conflict between USDA, which during normal times would determine standards of meat quality, and FEMA, which during emergency times should be prepared to set guidelines for departures from the normal situation. Ultimately, the question of which meat to process might be answered by conventions adopted at the small, decentralized slaughter houses in rural areas. Such decisions may or may not be based on sound reason.

4.5 NEAR-TERM COPING ACTIVITIES

The remaining actions addressed in this section are intended to bridge the gap between starvation and re-establishment of the normal food system. Such actions would generally be necessary only in the event of a massive catastrophe: a nuclear war, an asteroid impact, a calamitous crop failure, a change in climatic conditions, etc. The overall time frame for such actions would depend upon the time period necessary to restore food production. It is possible that near-term feeding efforts from stocks could be sustained well beyond a single growing season (Kerley and Das 1985), though whether or not a single disaster could cause such a need is not well understood. Examples of such disasters are a protracted nuclear exchange, a brief but intense nuclear exchange that generates large quantities of smoke and particulate materials, or a temporary climatic change from other causes that adversely affects agricultural production. Here the challenge would be to make use of existing foodstuffs, once the processed foods discussed by Billheimer are no longer available.

The solution most often suggested in this regard is to make use of the unprocessed grain stockpiles managed by USDA in a way that would make them available if the need arose (Garland 1972; Blanchard 1982; Kerley and Das 1985). Other solutions would be to stockpile grains in permanent reserves, which would not fluctuate with market conditions, or to stockpile processed foods. These possibilities have generally been rejected as being prohibitively expensive (Blanchard 1982).

The same basic issues surround the concept of a food reserve based on USDA stock as surround the shorter-term coping actions. Nutritional requirements are a primary matter. Kearney (1979) has analyzed the nutritional contents of a variety of grain-based diets and has indicated potential weaknesses. He recommends, for example, expedient ways of supplementing vitamins by eating sprouts, obtaining iron by cooking with iron pots and pans, and treating corn with lime to avoid niacin deficiency (pellagra). Other concerns might include using water untreated with chlorine and using salt unfortified with iodine. As was discussed previously, these issues, although generally quite well understood by nutritionists, are unfamiliar to most families because of the abundance of the typical American diet. Although the Kearney volume is highly useful, a simple guide for family units which addresses this topic in a nontechnical way would also be useful.

A second issue concerns institutional arrangements to provide incentives for farmers and others that hold grain stocks to participate in a reserve activity as USDA stocks were depleted. For example, in one of its exercises, FEMA has explored an emergency credit income system

(FEMA draft). This general topic is reviewed more thoroughly by Hill (1985).

Plans to facilitate transfers over the longer term must also be prepared in advance of the need to act. Grain reserves are highly volatile and change from year to year and from season to season and are also affected by changes in agricultural policy by the federal government. They are generally lowest in the spring before the spring wheat harvest and highest in the fall following the summer wheat harvest (Kerley and Das 1985). Thus, the timing of a disaster may affect the ability to respond. While large reserves are owned by USDA, a larger amount is held by farmers in private storage (Kerley and Das 1985). Effective planning dictates that current records of inventories be maintained by emergency planners who would deal with the reserve, not only to identify sources of grains to facilitate orderly transfers but also as a check on field reports that would develop as the programs were implemented. Following any major weapons exchange, there would probably be an imbalance of stored grains between producing regions and consuming regions. Those regions with excess reserves have strong reason to underreport available stores (Blanchard 1982).

Finally, an issue raised by many authors concerns the palatability of raw grains as a continuing diet (e.g., Kearney 1979). It is insufficient to reject this issue as nugatory on the grounds that, throughout the world, groups can be identified that exist on such rudimentary fare as goatsmilk cheese, mushrooms, and insects. Such foods, though of nutritional content, are far removed from the typical American's experience and would likely have a depressing effect on

morale. It would be useful to develop a series of recipes making use of raw produce, as described in Dickey (1969), that could be distributed if the need arose.

4.6 CONCLUSIONS

This chapter has reviewed short-term food emergency coping activities by examining action across several time frames. The most detailed preparation appears to exist for preattack redistribution of processed food items. Independent review of these plans to assess their likely efficiency would be advisable, if it has not been done already. Most literature deals with transincident emergency food activities related to feeding a population sequestered during a nuclear attack. Although the literature answers most questions needed to develop a rations program, no such program has existed for several years. If a new program were implemented, the newer food preservation literature should be carefully reviewed. To the extent that no formal shelter rations program exists, reliance is placed on individuals to assemble their own stocks. Publications that provide guidance in these endeavors would be useful.

Following a disaster, immediate feeding issues take precedence. This requires locating populations, determining food needs, transporting food, and distributing it. Currently, there is virtually no way to determine where persons evacuating cities would settle. Studies should be done to indicate ways to anticipate the redistribution of population. Systems to transport and distribute food should be very flexible because this information would likely be obtained only as food deficiencies

appeared. The state level is likely the most useful agent to administer food distribution. In general, nutritional needs are well understood by nutritionists. However, clear, easy-to-use guidelines have not been developed for individuals who wish to control their intake of needed nutrients.

Difficulties in the transport and warehousing of foodstuffs following a disaster would vary with the scope of the disaster. Truck transport appears to offer the most flexible option. A major warehousing issue concerns the need for electricity in refrigerated warehouses. Many warehouses have backup generators, but the growing tendency to use frozen food may reduce the usefulness of the stored food stock.

Screening of food products following a nuclear attack provides a number of difficulties because of the public's general lack of knowledge about radiation. Perhaps the most difficult issue pertains to live animals that may suffer from radiation sickness. Although some basic research has been done in this area, no clear guidelines have been prepared regarding decisions to slaughter, cook, or discard these animals.

Finally, the nation's grain stores that have resulted from various farm programs remain an attractive option as a national food reserve. Kerley and Das (1985) are now in the process of updating data and procedures on this subject.

5. LONG-TERM COPING ACTIVITIES FOR NATIONAL FOOD EMERGENCIES

5.1 INTRODUCTION

In considering long-term national food emergencies, attention is directed toward actions that will restore the food system to its predisaster condition. In general, any or several of the components of the food system could be the target of coping activities, though emphasis tends to be on rebuilding supply systems rather than on feeding. Disruption of these components could result from any of the causes discussed previously (Chester 1984; Cochrane 1974; FEMA 1980, 1983, 1984; Patak 1964; Ruffner and Barr 1977). Typically, long-term actions would follow or be coincident with short-term activities, though this is not necessarily the case. Examples of emergencies of this scale are, fortunately, much less common than those requiring short-term actions. The most recent example in the United States was an earthquake centered in New Madrid in the early 1800's, although the Mt. St. Helens eruption possessed many similar characteristics for the local forestry industry. There were fears that the Three Mile Island incident could contaminate farmland or otherwise disrupt food industries in the immediate vicinity, though this did not prove to be the case.

Published reports dealing with the issue of long-term coping activities frequently emphasize that in the event of long-term emergencies, mitigation measures directed at re-establishing the food supply could involve many other sectors of the economy (Adelman 1976, FEMA 1985, Oliver 1982, USDA 1977). Federal, state, and local agencies responsible for industrial production, power supply, chemicals,

petroleum, transportation, and related services would likely be required to work hand in hand with FEMA, USDA, Health and Human Services, and DOT in restoring the food supply sectors. In some cases, re-establishing agricultural production would await the availability of critical materials. Hence, the need for coordinating agricultural development activities with those for other sectors is more important in the longterm than in the shortterm. For a more general discussion of long-term economic recovery from disasters, see Hill (1985).

5.2 FARMING

Most of the published reports agree that labor supply for farms should not be a major issue in assuring continued farm output. This finding is based on the observation that farming in the United States tends to be widely dispersed and that a single emergency would be unlikely to wipe out a significant fraction of the activity. As regards nuclear war, most agricultural labor tends also to live in rural areas that are likely to be subject to fallout, rather than to direct attack. This suggests that labor would generally be available for farm activities (Jackson 1980, Laurino et al. 1980, Sharfman 1979). An exception is provided by Brown et al. (1973), who give detailed estimates of survival rates for a simulation conducted in Fresno County, California. In this instance, Brown describes model results which indicate that farm labor inputs were significantly impacted because only one-third of the general population of Fresno County was "... effectively uninjured and able to carry out able-bodied activities ...". The (simulated) attack came at a time when farm labor would normally be in high demand; over 20,000

seasonal laborers work during June, in addition to 20,000 farmers and regular hired farm laborers. Although about 80 percent of these seasonal laborers come from within Fresno County, many live in Fresno and other towns at some distance from the farms where they work."

Brown also reported that the minimum shelter time in the county was five days and the maximum in a more heavily impacted county was much longer. The point to be made here is that the farm sector is a highly heterogeneous activity and that conclusions drawn for Fresno would likely not be valid for Sioux City, Iowa. On the other hand, certain farm activities, in certain parts of the country such as Fresno, could well be devastated.

Also, the literature tends not to draw distinctions between farm labor and farm management or to recognize special skills that many laborers possess. In certain stages of the crop year (for example, at harvest), it may be that many persons with farm experience could take over an operation. In contrast, at other stages, when specialized chemicals are applied, both experience and records of planned actions may be necessary. In certain portions of the country, special management skills are necessary for large farm operations; if these skills became unavailable, operations would suffer. Even unskilled labor may be substitutable in only limited degrees. For example, typical middle class families might be able to supply themselves with fruits from an orchard, but they would find it very difficult to match the productivity of migrant worker families who are experienced in the hardships of manual harvesting. Overall, some labor-related bottlenecks may be overlooked by the literature.

A second potential vulnerability of the agricultural sector is in the area of energy products. Farmers require large quantities of a variety of fuels on very strict timetables to obtain normal yields. Supplies of some of these fuels, particularly petroleum products, may be very diminished following a major emergency as a result of damage to petroleum refineries and transportation networks (Goen et al. 1970). Some authors have suggested that agricultural energy needs in some areas could be met using biomass-based fuels. In a detailed review of this argument, Bjornstad et al. (1982) found that virtually all energy needs on farms could be met by using these fuels but that there is little economic incentive to do so during normal times. Under emergency conditions, it would be possible to meet many short-term energy requirements by, for example, burning vegetable oil in diesel tractors, but doing so would require farmers to take extraordinary precautions because vegetable oil could cause coking of injectors and breakdown of engine lubricants. Also, vegetable oils rapidly solidify in cold weather. Nevertheless, a good deal of information is available that could make vegetable oil, and also other biomass fuels, a practical short-term option (American Society of Agricultural Engineers 1982).

Fuel shortages could have disruptive effects in other ways as well. Vast quantities of natural gas are used to fuel irrigation pumps in arid regions and are indirectly responsible for the high productivity levels of these regions. Without this fuel, yields would be significantly lower.

Fertilizer and pesticide availability is also highly necessary for attainment of customary crop yields. Fertilizer availability is largely

subject to the same constraints as energy supplies because nitrogen fertilizers are based upon petroleum products, especially natural gas. It is, however, also true that fertilizer plants are often decentralized along natural gas supply routes. Hence, the condition of natural gas pipelines would significantly affect fertilizer outputs.

In general, the availability of pesticides parallels the vitality of the chemical industry. This industry is dependent on skilled labor and continuous supplies of raw materials and tends to be located in highly vulnerable areas.

With regard to machinery, most studies anticipate little problem. Farming areas tend to be low probability targets, and, again, the agricultural sector is quite dispersed (Ayres 1965a). This, coupled with the general tendency of farms to be overcapitalized and the relatively large inventories held by rural implement dealers, suggests that machinery should be little problem (Ayres 1965a, Bull 1973), even though some authors argue that there would be little new machinery produced for some time after a nuclear attack (Cannel and Schuert 1980). Small- and medium-sized farms, which tend to be owner operated and overcapitalized, most likely have a good deal more flexibility than the larger farms. These farms still produce a significant portion of the cereal products that could form the basis of an austere diet. Nevertheless, it should also be recognized that farmers, and particularly small farmers, may have insufficient credit or cashflow to make use of some available options unless extraordinary steps are taken to ensure that transactions are possible. This would be especially true in a postdisaster environment in which normal business transactions are disrupted. With the exception of

one unpublished paper, the literature largely ignores these concerns (see Hill 1985).

The general age of most of the studies dealing with farming and recovery raises a concern about their general validity for modern farms. For example, many modern farms are highly specialized and integrate their machinery stock with particular practices and products. A farmer with equipment for no-till seeding of corn, for example, must use a specific herbicide, a specific insecticide, and a specific liquid fertilizer. Without these, yields diminish rapidly. The flexibility of the farmer to change practices rapidly may or may not be present. The farmer may have disposed of his conventional equipment. Hence, estimates of yield reductions, such as are found in Advance Research (1962), may have little meaning for many farms. Also, the importance of timing in obtaining scarce supplies should not be overlooked. Because of the conditions discussed above, most farms do not have the financial resources to stockpile fuels and chemicals. They are thus dependent upon current production runs. Fortunately, USDA possesses most of the knowledge needed to update this work, but it has not yet been integrated into the emergency planning literature.

Finally, a potentially important issue is the possible effects of radioactive contamination on farm soils. Uptake of radionuclides in the soil from fallout is of primary concern. Measures to decontaminate soil for the next growing season include deep plowing and adding phosphate, lime, or potash to soils. Certain deep-rooted plants might also be chosen for the next year's crops. In general, fallout would not preclude

growing crops the next year. For a detailed discussion of this issue, see Baes (1985).

Agricultural production of meat, dairy, and poultry products is relatively capital intensive and increasingly dependent on modern equipment and facilities. Dairy and poultry production, for example, require significant use of electricity (Brown and Pilz 1969). Restoring the production of these commodities to normal would therefore be dependent upon the availability of electricity, i.e., on the ability of the power industry to recover from the emergency. Even if rural electric lines survived, it is quite possible that electric power restoration could take some time (Advance Research 1965, Brown and Pilz 1969). The degree to which production would be affected would therefore rest upon the dependence on delivered electricity and perhaps on the availability of backup generation sources.

Again, modern farms may be more dependent on specialized equipment than those reviewed by, for example, Advance Research (1965). Many farms now control electronically virtually all aspects of livestock handling. On these farms, livestock would likely be better sheltered and less susceptible to radiation sickness. Many of these farms also have auxiliary generators, which, while not capable of running all facets of the operation, could certainly help to avoid the most serious impacts. Damage done to the electronic components of these farms as a result of electromagnetic pulse could, however, have catastrophic impacts. In general, sophisticated electronic parts are not stockpiled in numbers sufficient to restore systems from inventories. Hence, the sector would

again be dependent on restoration of production in other parts of the economy before regaining full strength.

Finally, several authors have called attention to the possibility of climatological effects resulting from nuclear attack. An early review of the so-called "nuclear winter" scenarios may be found in Chester et al. (1984), Thompson and Schneider (1986), and Ghan et al. 1985. In general, recent work suggests that the massive temperature swings postulated by the early work in this area likely overstate actual temperature changes and that a "nuclear autumn" might better characterize temperature changes. However, a new issue, that of possible drought related to atmospheric changes resulting from a nuclear exchange (Ghan et al. 1985) has recently emerged. The implications of nuclear drought, if valid, would be reduced crop yields. Further research in this area should be carefully monitored.

5.3 AGRICULTURAL COMMODITY PROCESSING

With regard to agricultural commodity processing, analyses indicate that major emergencies may cause substantial damage to processing facilities (USDA 1977). This large damage potential results from the concentration of agricultural commodity processing facilities in areas of the United States that are subject to direct nuclear attack and, to a lesser extent, other emergencies. This proximity makes it reasonable to assume that a large proportion of processing facilities will be destroyed or damaged. Activities aimed at reconstructing these facilities will therefore be a major undertaking (Oliver 1982). One substantial information source regarding reconstruction is provided by Advance

Research (1965) in a detailed volume describing the types of facilities used in virtually all phases of food production, the level of damages that might be sustained, and the degree of difficulty that might accompany efforts at repair. Unfortunately, the volume is now 20 years old and is perhaps not applicable to much of the present food industry.

To the extent that processing facilities would be damaged because of their proximity to prime targets, a number of other complexities would arise. For example, work to reconstruct these at the same site must take place in areas where most residents would have evacuated. Hence, assembling a labor force may offer some difficulty. Similarly, fewer local resources would be available in the form of spare parts, equipment, and construction materials in general, and there would be competition for the available ones. Clearly, there would be a need to prioritize and coordinate activities if the food processing activity were to be promptly restored (Goen et al. 1969, USDA 1977).

Closely tied to the reopening of food processing activities is the matter of non-food inputs to food production. There are clear advantages to placing priorities on the re-establishment of processing operations for products with long shelf life requiring minimally sophisticated storage facilities. For example, 11 to 16 percent of total food consumption in the United States currently is of frozen or refrigerated foods. It would be desirable to drop this fraction substantially, given the potential limits on refrigerated transport, warehouses, and possible loss of electricity to many dwellings. This suggests the need to package many processed foods in containers made of tin, plastic, glass, or seal aluminum foil. By caloric content, about a third of food products are

now shipped in tin or glass containers. This fraction could increase in the face of a prolonged emergency condition.

Studies on this subject indicate that the present distribution of container manufacturing facilities in the United States is in urban areas, generally not at great distances from their client base. In an emergency that affected the food processing industry, these suppliers would also likely be affected (Oliver 1982). Therefore, containers for food products may also be in short supply, and efforts would need to be directed at the reconstruction of the container industry along a parallel with the food processing industry (Cannell and Schuert 1980).

Furthermore, the materials needed to manufacture containers (i.e., tin plate) would likely also be in short supply because these materials are located close to markets and would suffer damages. Hence, rehabilitation of the container industry would also require doing likewise to manufacturers of tin plate and other relevant inputs (Oliver 1982). In general, steps taken to reconstruct the food processing industry would require attention to a number of supplying industries, many of which would be competing with the rest of the industrial sector (Cannell and Schuert 1980). The methods chosen to adjust these priorities therefore take on an increased importance [see Hill (1985) for a general discussion of economic institutions and the post-emergency economy].

5.4 FOOD TRANSPORTATION

Transportation facilities of agricultural commodities and processed foods may be severely damaged or destroyed in the event of a large

national emergency. Destruction of facilities may delay the movement of food products either to processors or from food processors to consumers (Bigelow and Dixon 1963). Of course, to the extent that damage occurred, food transport would also compete with transport of other goods, though transport of food would undoubtedly receive a high priority. Coping activities in this area must deal with repair of transport facilities and equipment specialized for food applications, and with prioritization of food transport needs relative to other transport needs. Dixon et al. (1960, 1964, 1967) provide a detailed discussion of nuclear attack impacts on various transport modes.

There is significant overlap between short-term and long-term transport issues related to food; however, in general, short-term efforts would be concerned with moving foods, in processed or unprocessed forms, from inventories to consumers. Emphasis in the short term would also be on minimizing transport distances, whereas in the long term, when fewer local inventories would be available, more attention must be given to balancing diets. Thus, though it may also occur in the short-term, long-term food transport issues generally involve long-distance transport.

Two characteristics of long distance transport of agricultural commodities may complicate transport-related activities. The first relates to an issue already raised--the need for such specialized equipment as bulk or refrigerated facilities. The second relates to the fact that whereas a large proportion of agricultural commodities and processed foods are transported by truck and/or rail, certain important

commodities such as grain are transported almost exclusively by rail (Dixon and Tebben 1967).

In the event of significant damage to transport systems in the United States, highway transport would be most effective because of the flexibility it offers in choice of vehicles and route selection (Dixon and Tebben 1967). Furthermore, the abandonment of many railroad lines in recent years may make it impossible to deliver significant shipments of agricultural commodities and processed foods by rail (Dixon and Tebben 1967). In general, foods and other high-priority shipments must compete for what will undoubtedly be a limited supply of trucks, drivers, and support facilities. Assigning priorities requires close cooperation among various agencies responsible for food supplies and those responsible for the reconstruction of damaged transport facilities. The literature suggests that an ample supply of transport vehicles will be available after a major emergency (Dixon et al. 1960, Haaland 1977), but the effectiveness of this stock will be diminished by destruction of physical facilities, such as bridges, tunnels, and terminals, which, unless anticipated, could cause massive bottlenecks (Bigelow and Dixon 1963, Hall and Hamberg 1970). Finally, two other basic modes of transport, air and water, could conceivably be involved in the movement of food supplies. Available analyses of long-term food emergencies generally reject these modes as less viable than road and rail transport. Air transport tends to be too expensive to supply foods, and water transport is subject to bottlenecks in the form of collapsed bridges and nonfunctioning locks.

5.5 CONCLUSION

Long-term activities to re-establish the food supply sectors to normal conditions must generally be integrated more with efforts to restore other sectors of the economy than short-term emergency food activities. Whereas short-term activities focus principally on emergency feeding and are clearly of high priority, long-term food sector redevelopment must compete with other redevelopment activities. Priorities assigned to food recovery efforts will, of necessity, reflect the exigencies of the time.

Most constraints to the agricultural sector will tend to arise from the availability of fuel, pesticides, fertilizers, and herbicides. Labor and equipment should not be in short supply, except in certain sectors, such as fruits and vegetables. In some cases, returning to more traditional forms of crop rotation can reduce dependence on chemicals. It may, indeed, be more difficult to process foods than to grow them in the wake of nuclear war. Processing facilities tend to be located in large urban areas that could be subject to attack during a nuclear exchange. These facilities depend on a variety of inputs that may be similarly in short supply. Recovery of the food supply sector is therefore closely tied to recovery in other sectors.

Long-term transport issues tend to parallel short-term issues, with the exceptions that, in the long term, distances traveled and competition for scarce transport resources would increase. A prime goal should be to identify potential bottlenecks to restoring rail networks. Using trains

for key food movements could allow large numbers of trucks and related resources to be used for other purposes.

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**EMERGENCY FOOD DELIVERY:
A STATE-OF-THE-ART ASSESSMENT**

Unclassified
August 1987
112 Pages

by David J. Bjornstad, F. Paul Baxter, Ivars Gutmanis
Interagency Agreement: FEMA No. ERM-84-E-1737, DOE No. 1457-1457-A1

The purpose of this report is to provide a critical literature review of the state of the art in emergency food supply issues, to relate these issues and literature to the mission of the Federal Emergency Management Agency (FEMA) and to recommend areas where improved information and documents would allow FEMA to more effectively perform its mission. Four major topics are addressed: (1) the institutions which participate in emergency food delivery; (2) the factual dimensions of U.S. agriculture as they relate to emergency food delivery; (3) short-term emergency feeding issues; and (4) long-term emergency feeding issues.

Several recommendations are developed which deal with the following: (1) FEMA should develop a more detailed working relationship with the Department of Agriculture (USDA); (2) FEMA should prepare better documentation of its own emergency feeding procedures and guidelines; (3) FEMA should test some previously developed options; (4) FEMA should evaluate several past studies to determine their current relevance; and (5) FEMA should undertake several new studies.

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